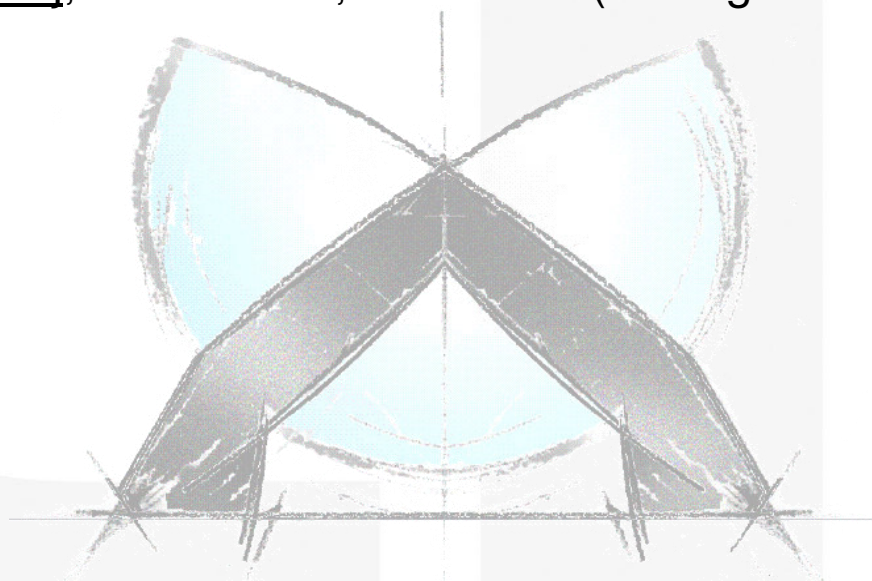


4a impetus (PART 2): Innovations – test methods, anisotropy, composites, *MAT_157 and more

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

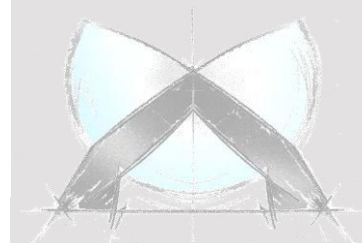


14th German LS-DYNA Conference
10th – 12th October 2016, Bamberg, Germany

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

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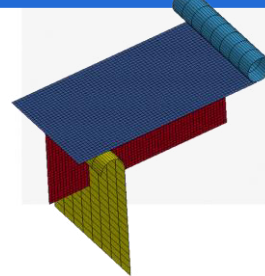
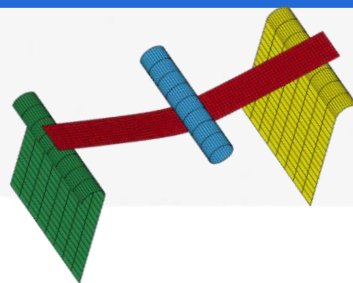
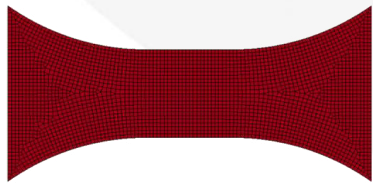
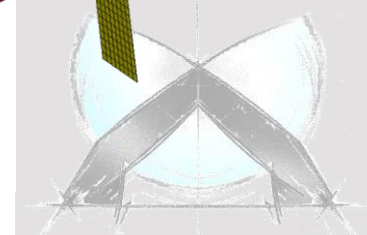
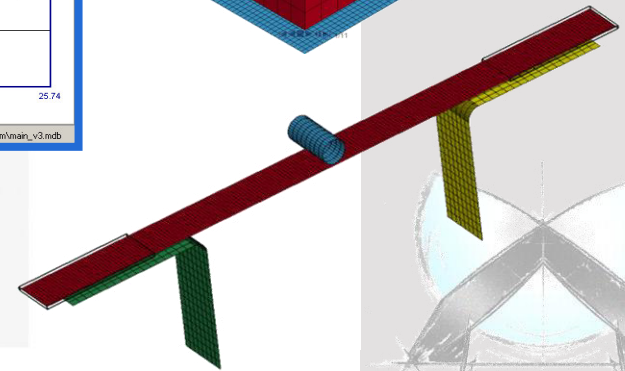
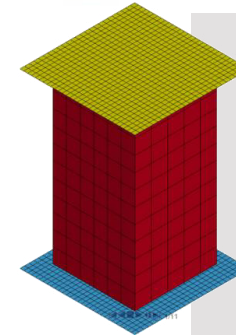
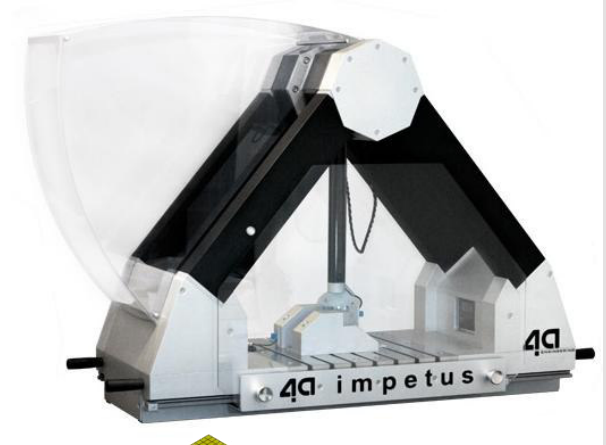
- Introduction
- 4a impetus – New features
 - Software
 - Licensing – token concept
 - MPIP – material parameter identification process
 - Material models
 - Anisotropy - Composites
 - Hardware
 - New pendulum arm
 - New puncture test
 - High-speed camera
- Summary



History, basics and advantages of 4a impetus → Part 1

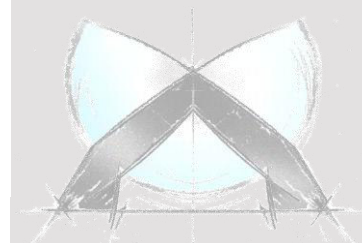
Complete system from the test to the validated material card

Parametermodell	Modelle
Datum_Nr	Name
110601_001	
Material	Destinat
Modellinstellungen	
Werkstoff	
Materialklasse	
Materialtyp	Thermoplast unv.
Materialverhalten	
Materialquelle	benutzerdefiniert
Materialkarte	339
Idealisierung	
Einheitensystem	SI(kg-m-sec-Pa)
Solver	LS DYN4
Inputdeck	customized
Modellsymmetrie	Viertelmmodell
Elementtyp	Solid Hexaeder
Elementgröße	2
Kontakticke	0
Elementschichten	0
Benutzerdefinierter Parameter	0



Incitement and objectives of our innovations

- **More detailed material models** are available
 - better description of the material behavior of plastics and composites
- New developments in testing are necessary to **measure** the needed **material behavior**
- Due to **increasing** material data and model parameters
 - automation is a key enabler
 - Focus: to offer an efficient **material parameter identification process (MPIP)**

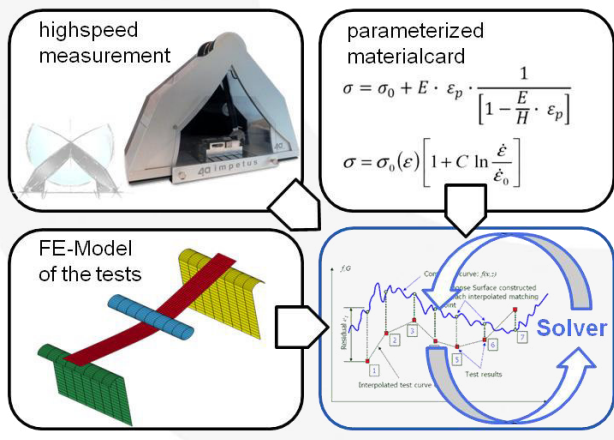
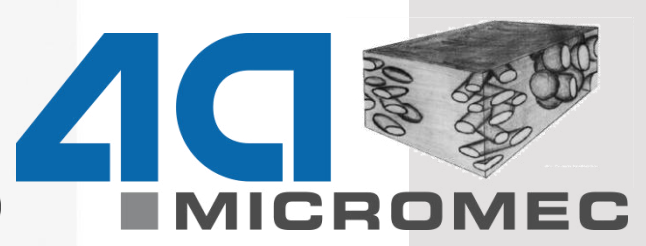
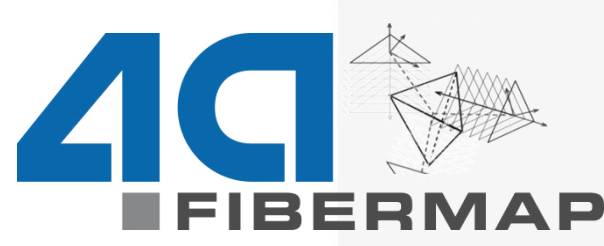


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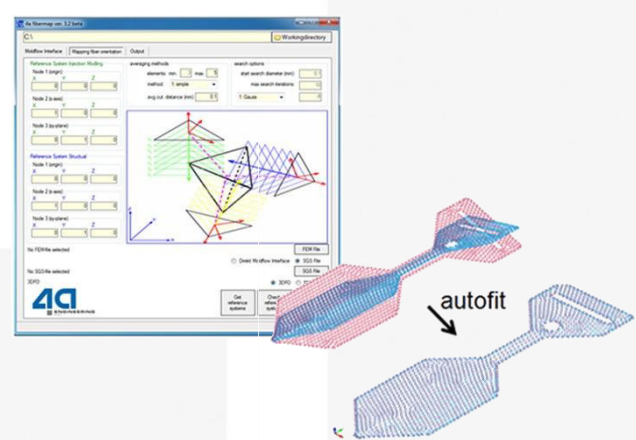
4a impetus – new software features

Licensing

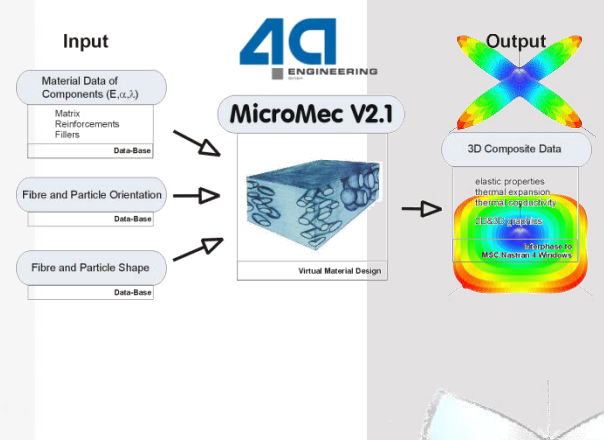
- Introducing new token concept
- Software products **4a impetus**, **4a fibermap**, **4a micromec** and their modules are now accessible



validated material cards



individual mapping process information



3D thermo elastic anisotropic material cards

4a impetus – new software features

MPIP - Material Parameter Identification Process

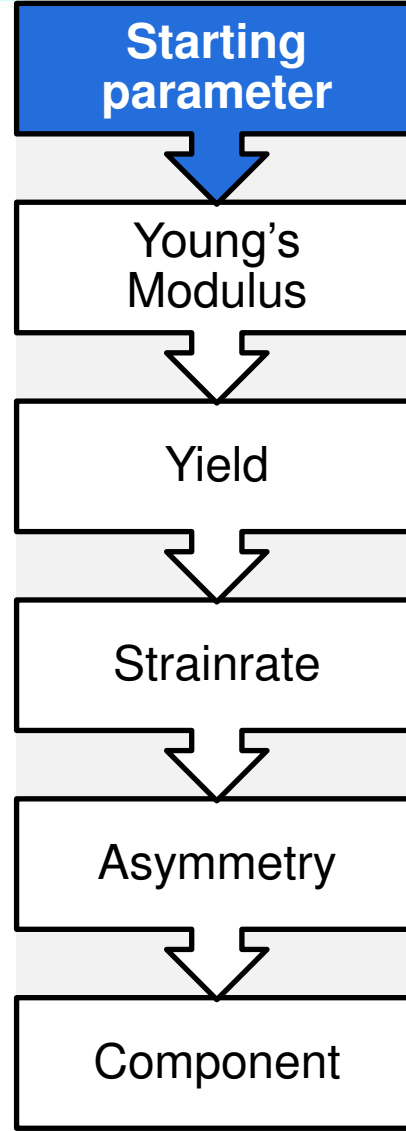
Automated optimization

ID	Name	Optimization/Validation	Status	VP Autovalue
161124_001	Young's Modulus	Optimization	✓	<input type="checkbox"/>
161124_002	Plastic data	Optimization	✓	<input type="checkbox"/>
161124_003	Strain rate dependency	Optimization	R	<input checked="" type="checkbox"/>
161124_004	Validation	Validation	✓	<input type="checkbox"/>

ID	Name	Optimization/Validation	Status	VP Autovalue
161124_001	Young's Modulus	Optimization	✓	<input type="checkbox"/>
161124_002	Plastic data	Optimization	✓	<input type="checkbox"/>
161124_003	Strain rate dependency	Optimization	R	<input checked="" type="checkbox"/>
161124_004	Validation	Validation	✓	<input type="checkbox"/>

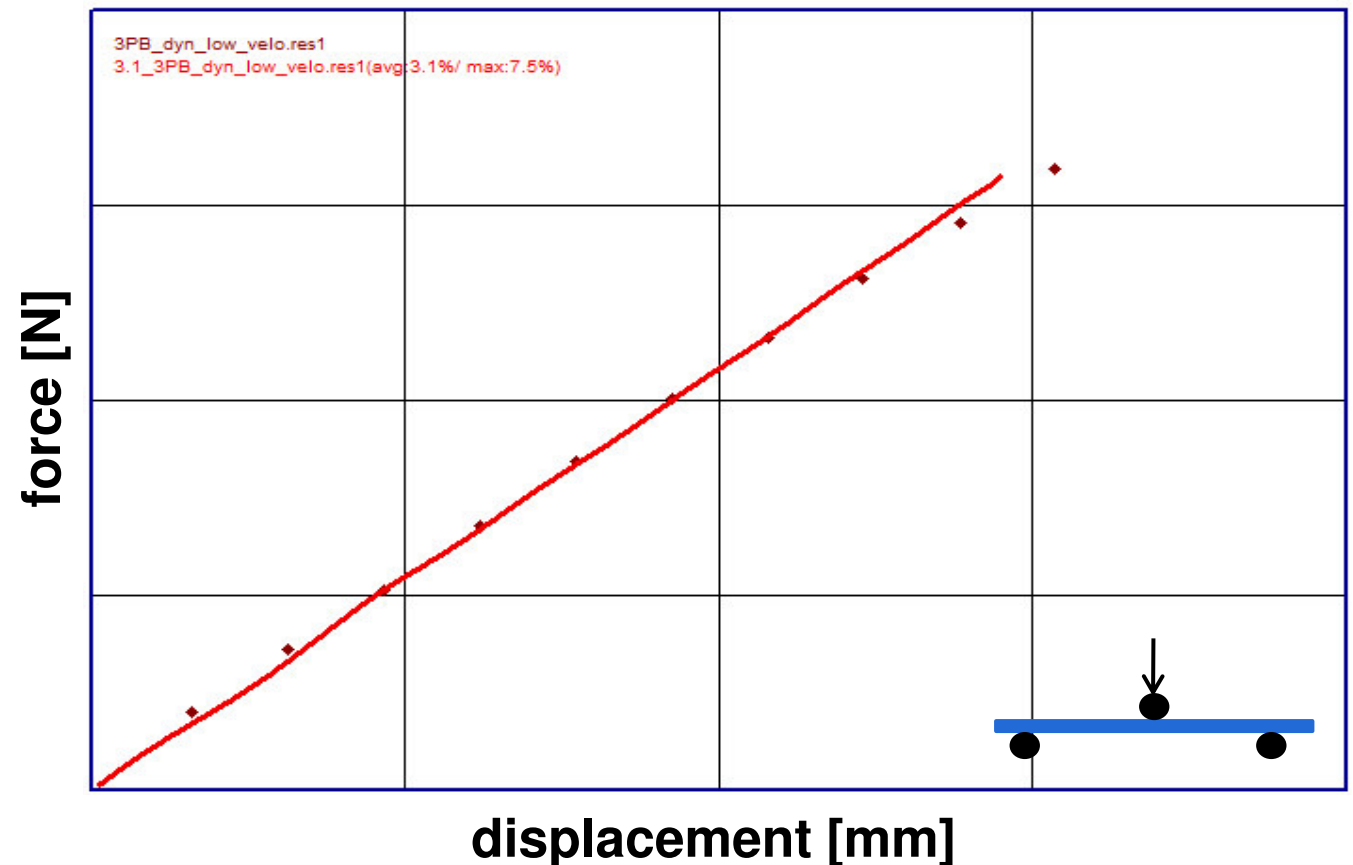
calc max strain 0.2 [1]
 calc strainrates 0.0001 - 100 [1/s]

DV	Autovalue	161124_001	161124_002	161124_003	161124_004
e_E	2009.4	2049.762	2049.762	PRUN(c)	PRUN(c)
e_nue	n.a.	0.3	0.3	PRUN(c)	PRUN(c)
y_0	15.344	n.a.	12.2752	PRUN(c)	PRUN(c)
h_y	n.a.	n.a.	12.2752	≠y_0	≠y_0
h_ET	-1.4782	n.a.	1024.881	PRUN(c)	PRUN(c)
h_h	15.344	n.a.	7.672	PRUN(c)	PRUN(c)
v_p	9.5407	n.a.	9.5407	AUTO	PRUN
v_epspt	0.0001	n.a.	0.0001	AUTO(c)	PRUN(c)

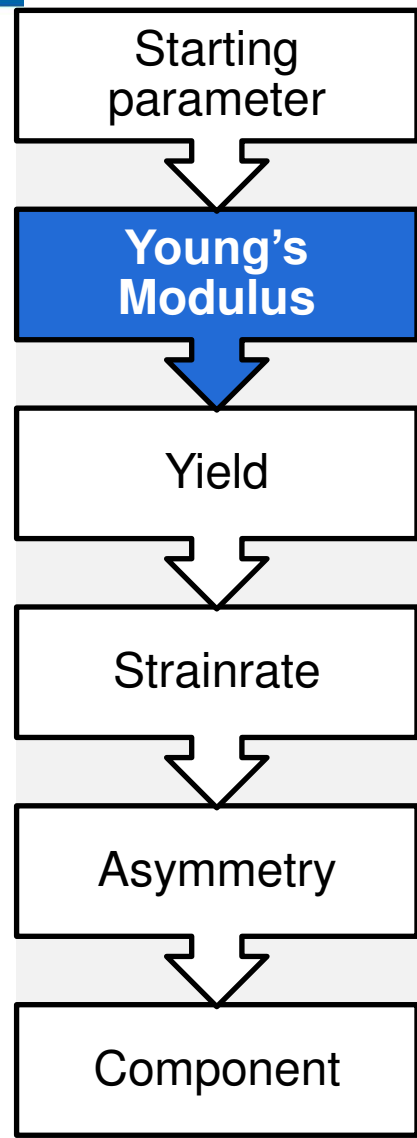


4a impetus – new software features

MPIP - Material Parameter Identification Process

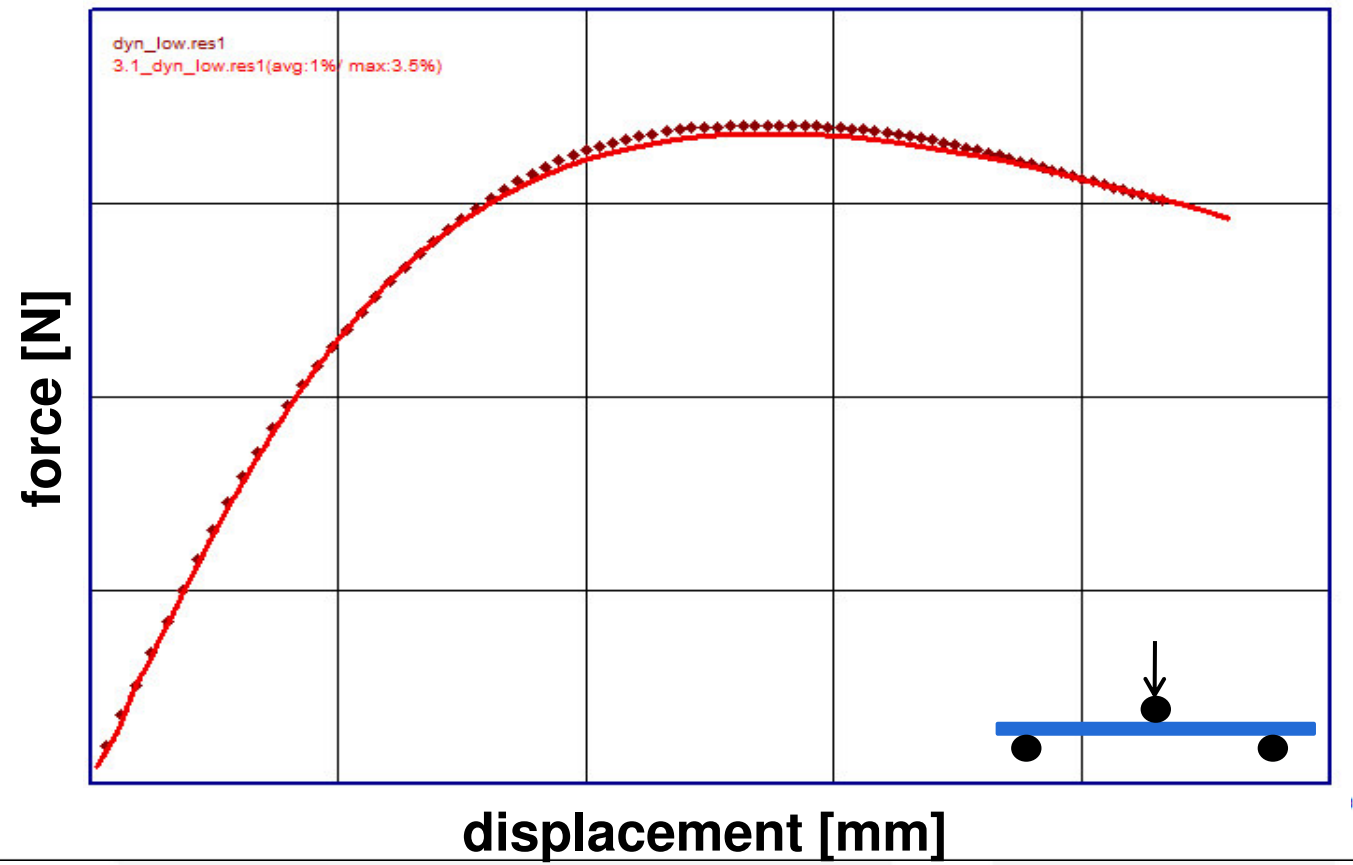


V_0
[m/s]
1

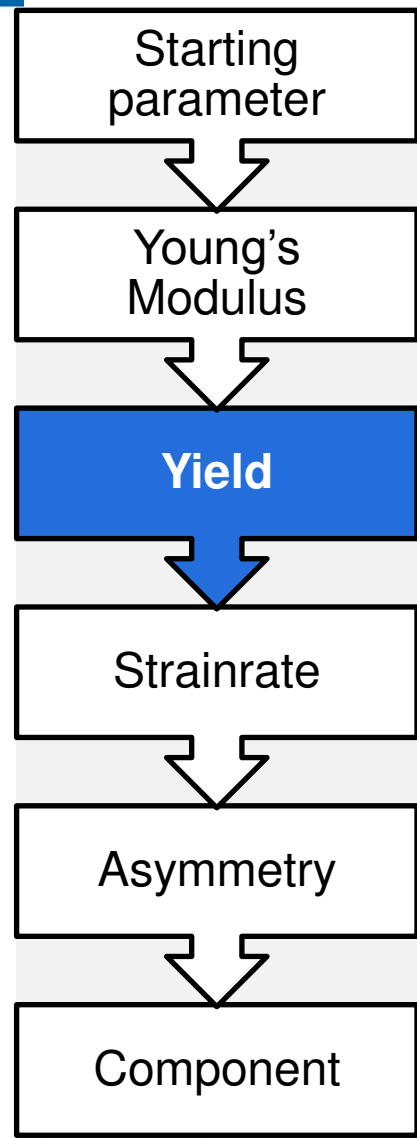


4a impetus – new software features

MPIP - Material Parameter Identification Process

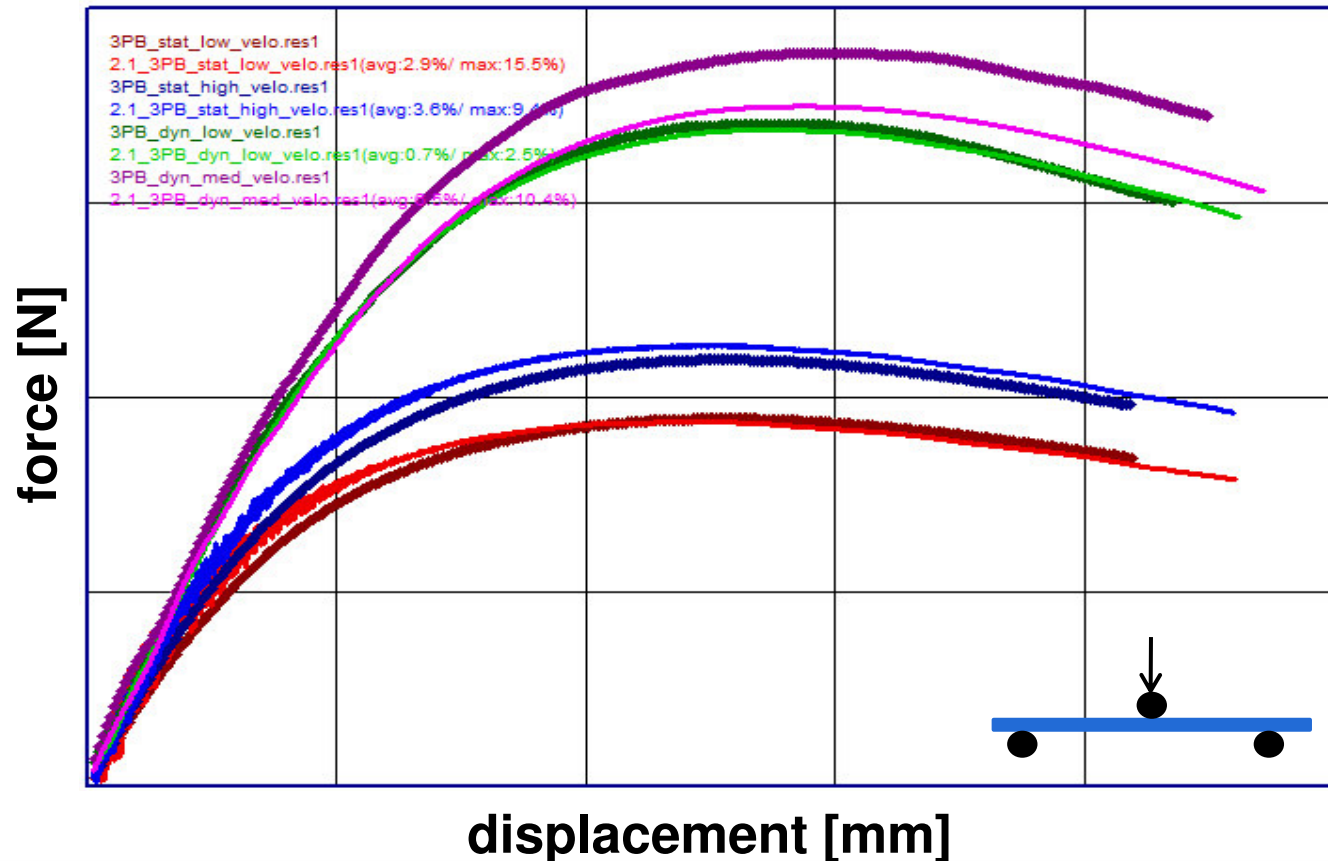


v_0
[m/s]
1

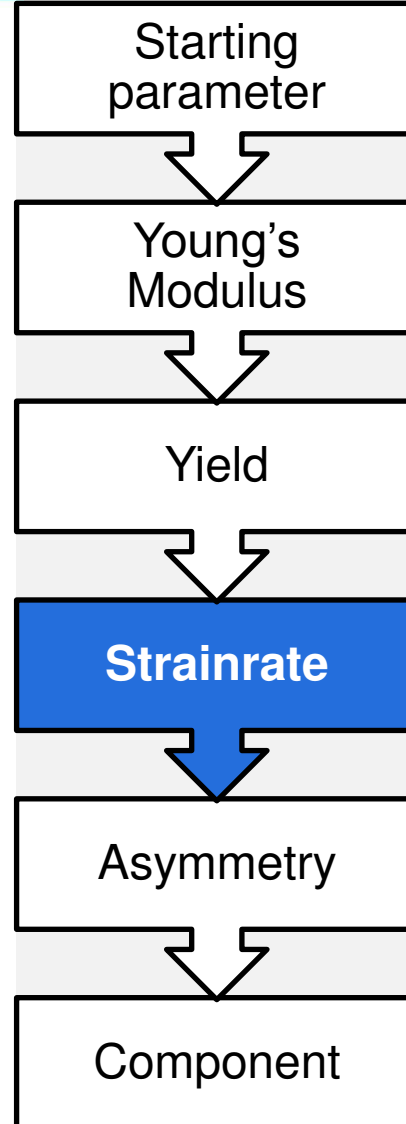


4a impetus – new software features

MPIP - Material Parameter Identification Process

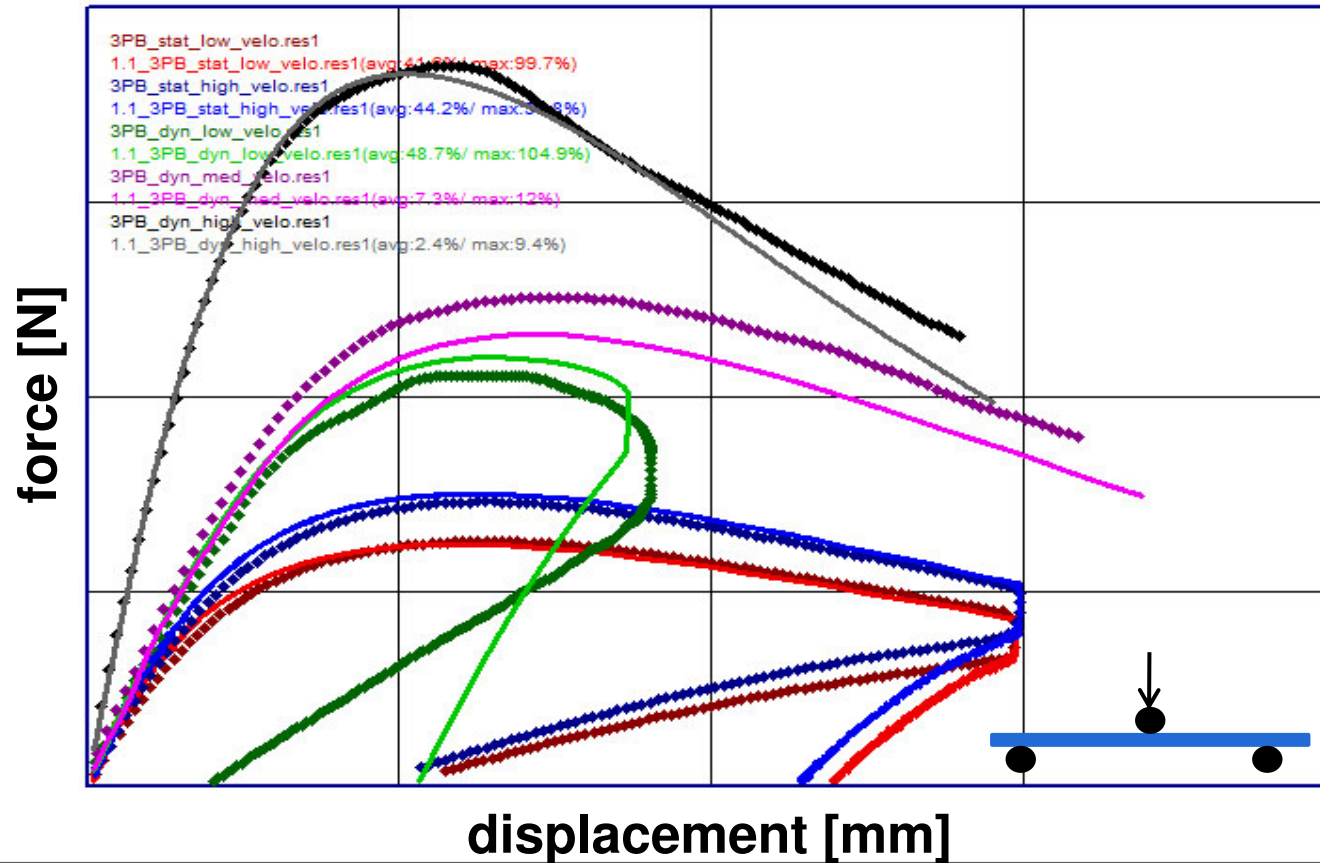


V_0 [m/s]
0.0001
0.001
1
2.5

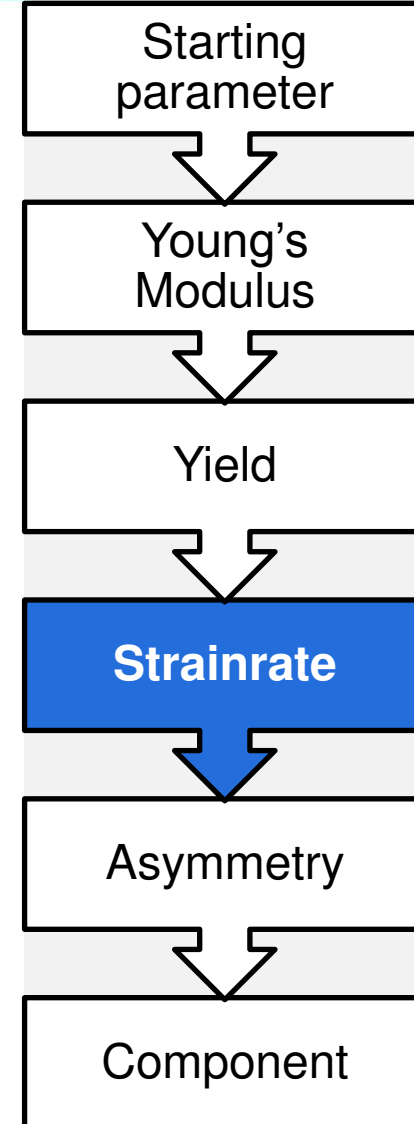


4a impetus – new software features

MPIP - Material Parameter Identification Process

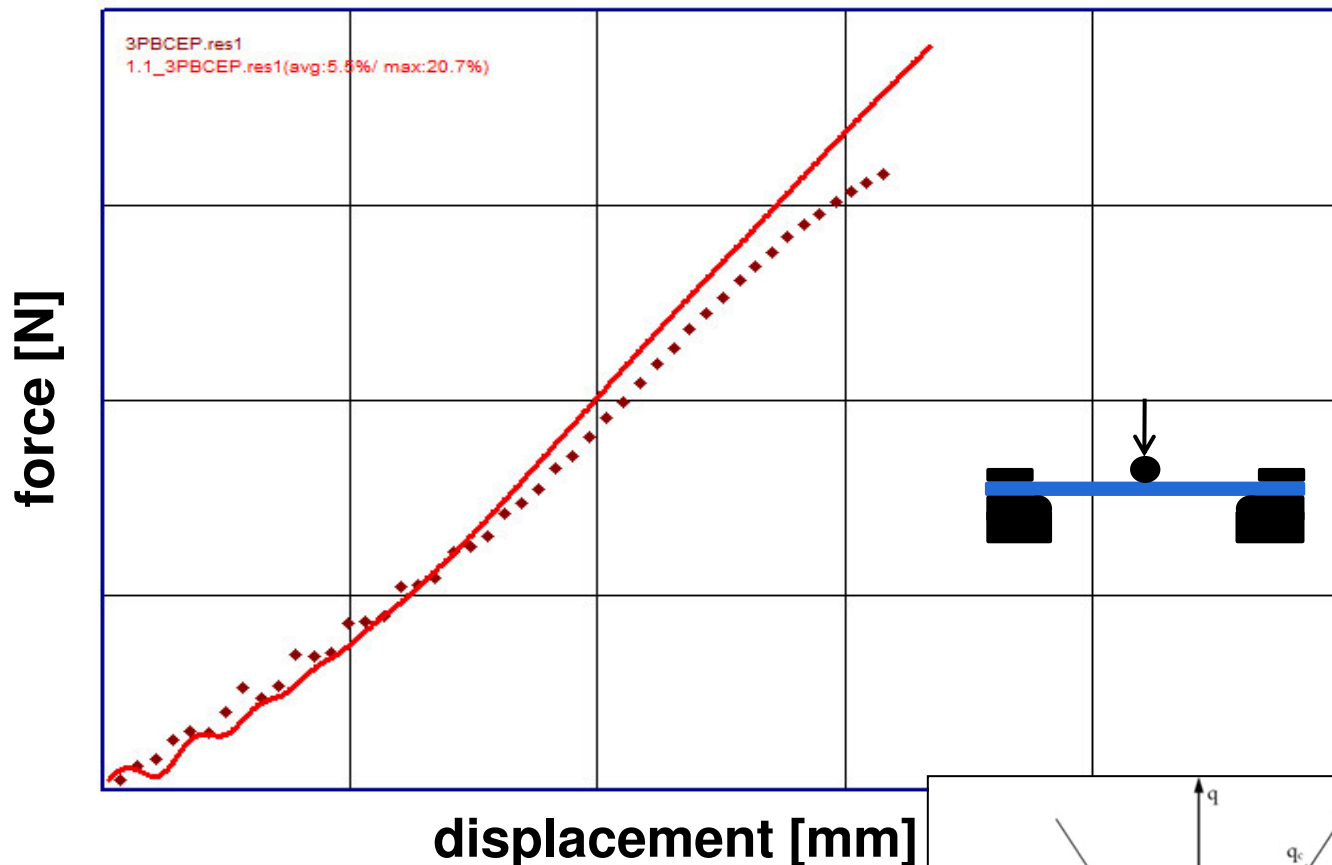


V_0 [m/s]
0.0001
0.001
1
2.5
4

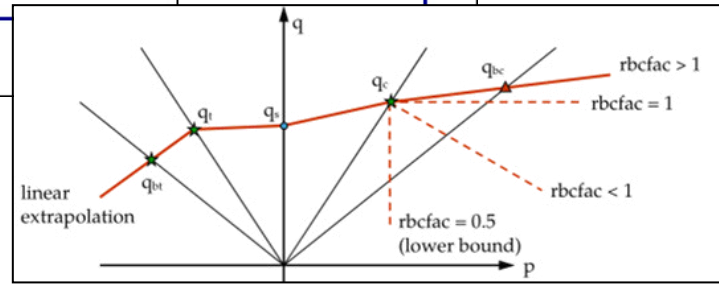
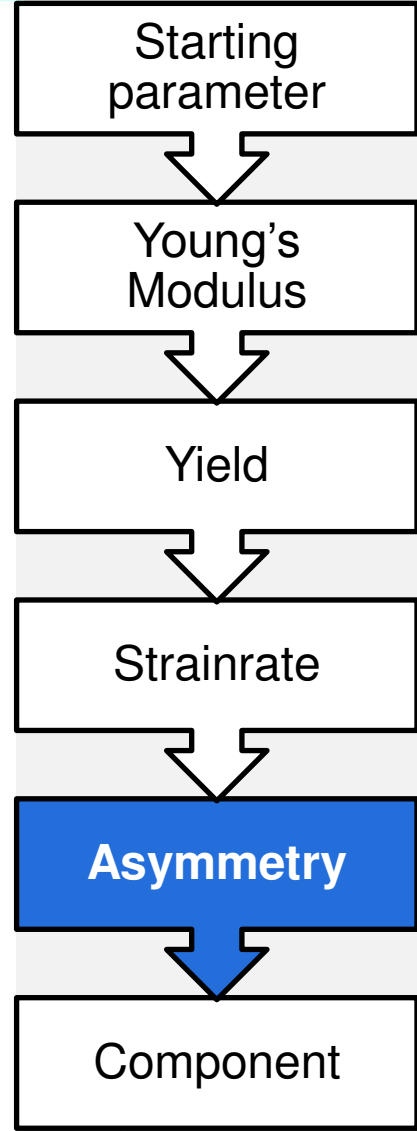


4a impetus – new software features

MPIP - Material Parameter Identification Process



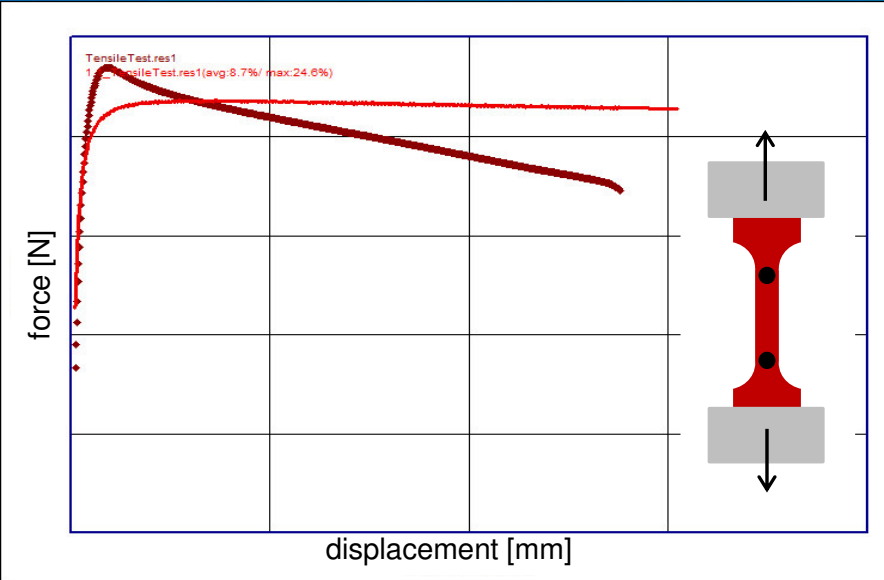
V_0
[m/s]
4



[LSDYNA MANUAL]

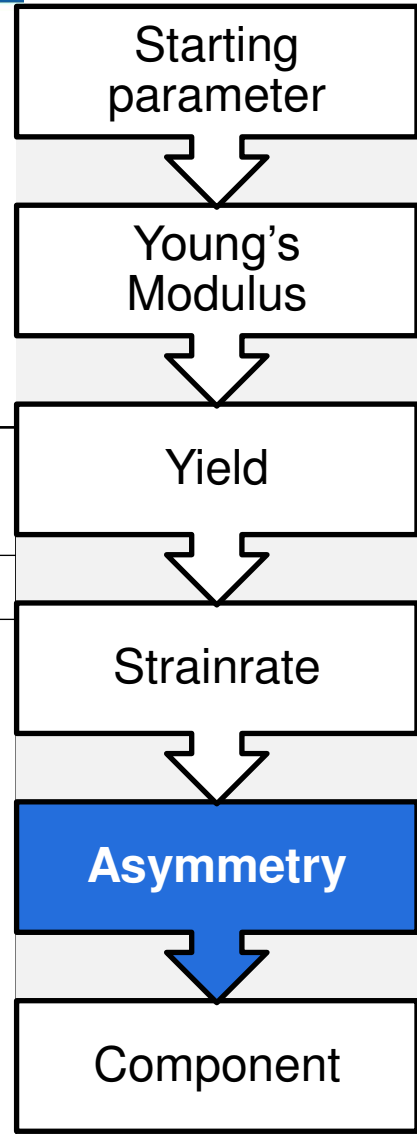
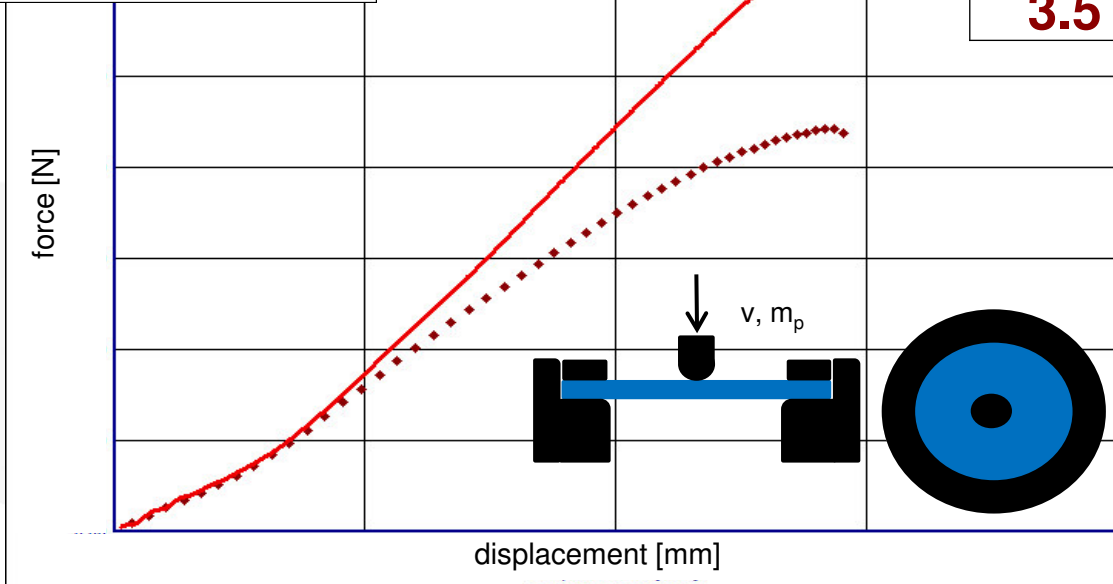
4a impetus – new software features

MPIP - Material Parameter Identification Process



v_0
[m/s]
0.001

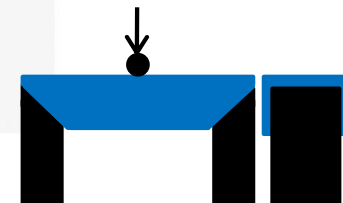
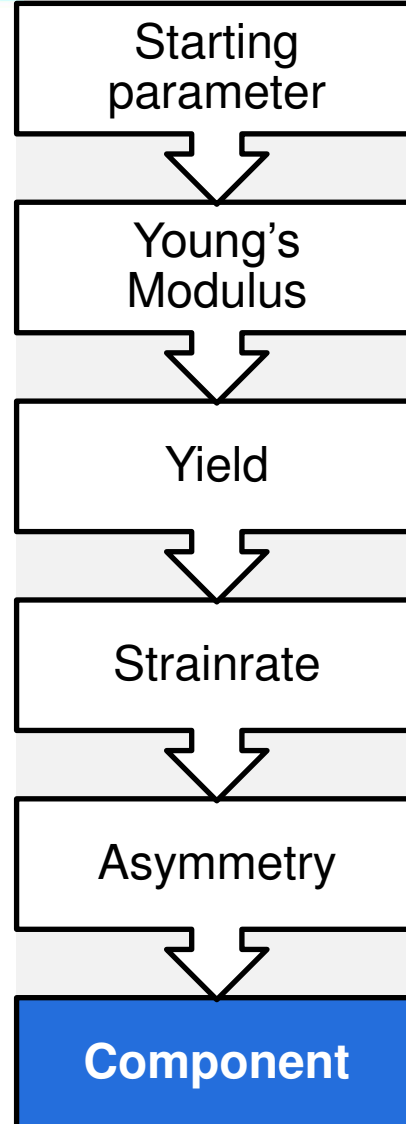
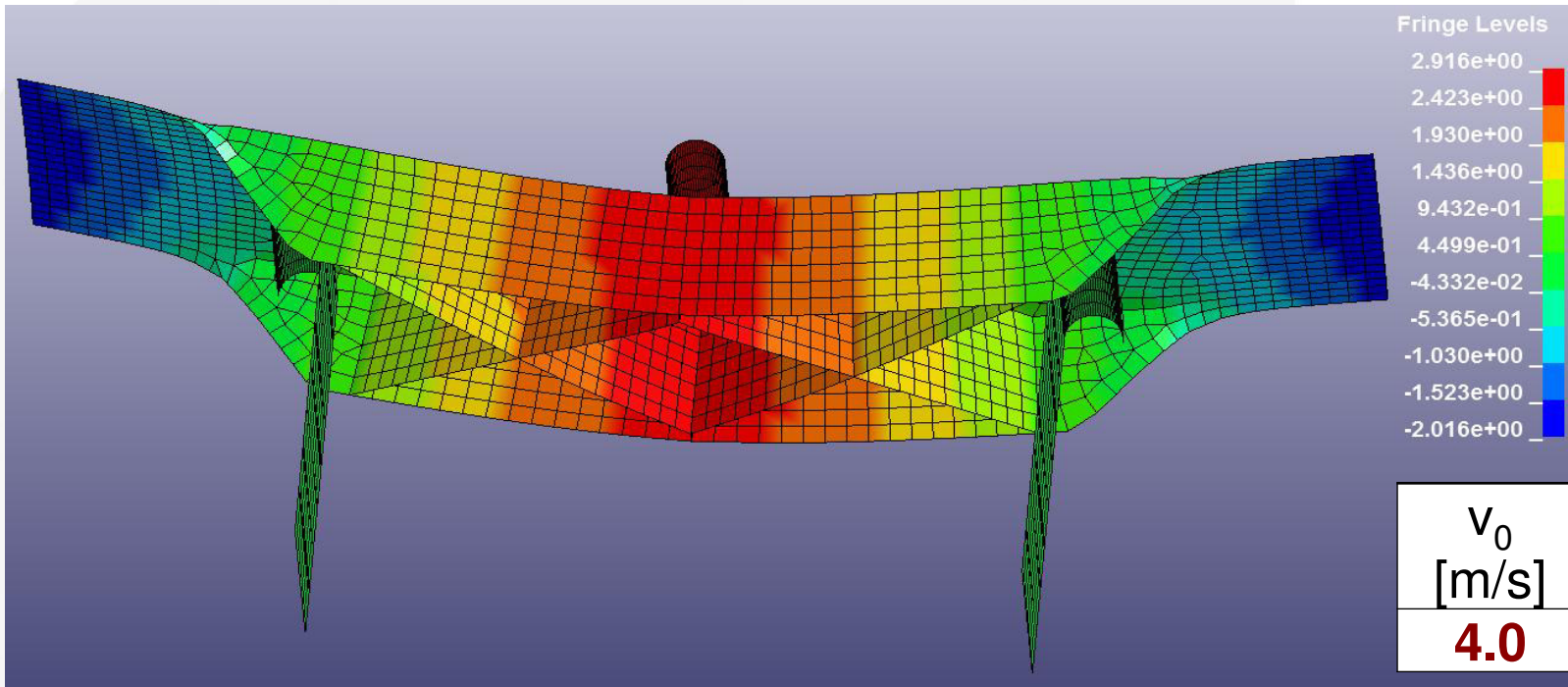
v_0
[m/s]
3.5



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4a impetus – new software features

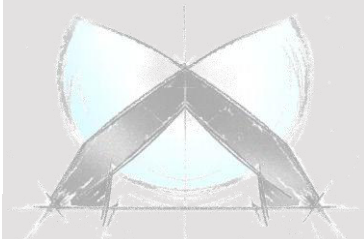
MPIP - Material Parameter Identification Process



- 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_COMPOSITE_DAMAGE (*MAT_022)
Function (Hardening, Elastic curve f	*MAT_ENHANCED_COMPOSITE_DAMAGE (*MAT_054)
Strain rate dependency	*MAT_LAMINATED_COMPOSITE_FABRIC (*MAT_058)
Micromec	*MAT_RATE_SENSITIVE_COMPOSITE_FABRIC (*MAT_158)
Fracture	*MAT_LAMINATED_FRACTURE_DAIMLER_PINHO (*MAT_261)
Postfracture	*MAT_LAMINATED_FRACTURE_DAIMLER_CAMANHO (*MAT_262)
Loadcases	*MAT_ANISOTROPIC_ELASTIC_PLASTIC (*MAT_157)
Results	*MAT_MICROMECH (*MAT_215)

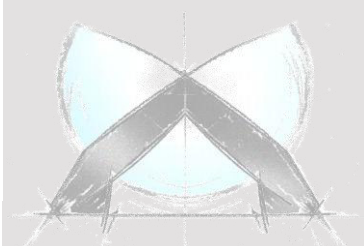
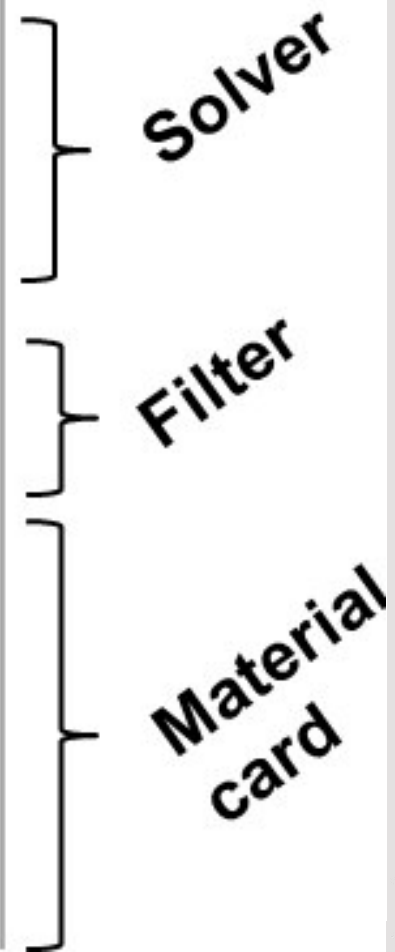
- Whole number of LS-Dyna material models is available through userdefined inputdeck



4a impetus – new software features

Material model – XML, filter

Model settings	
Material	
Material preset	MAT215
Material name	GLASS
Idealization	
System of units	t-mm-sec-MPa
Solver	LS DYNA
Inputdeck	Implemented
Symmetry of model	1-Element or more complex
Idealization type	Shell
Element size	1
Additional settings	
Material behaviour	
Material source	
Material source	Implemented
Elasticity	Not isotropic elastic
Plasticity	Not selected
Failure/Damage	Not selected
Material card	
Materialcardcase	*MAT_COMPOSITE_DAMAGE (*MAT_022)
Materialcard id	7500_MAT22
Damage/Failurecase	None
Materialcard id	1000000
Density	910
Plasticity	None
Function (Hardening, Elastic curve form)	
Strain rate dependency	None
Micromec	
Matrix	Endless fiber reinforced plastics



4a impetus – new software features

Material model – design variable table

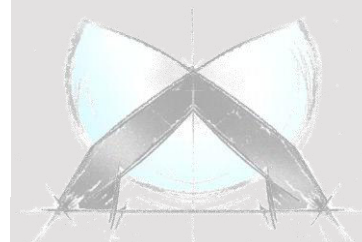
Parameter model* Model database

160623_007 Material Designvariablen Layers

Name	Start	const...	from	to	Variance	Condit...	Description
^ GroupName: 10_elasticity							
e_E	1500	<input checked="" type="checkbox"/>					youngs modulus
^ GroupName: 20_yield							
y_0	12	<input type="checkbox"/>	5	150	50		yield stress
^ GroupName: 21_hardening							
h_y	12	<input checked="" type="checkbox"/>	5	150	50	=y_0	hardening yield stress
h_ET	150	<input checked="" type="checkbox"/>	0	150	(NULL)	<e_E	tangent modulus
^ GroupName: 31_strainrate							
v_p	12	<input checked="" type="checkbox"/>	1	500			strain rate scale (1/vp)
v_epspkt	0.001	<input checked="" type="checkbox"/>	0.001	1			initial strain rate threshold
^ GroupName: 51_failure							
xf_NUM...	-65	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		Number of failed integration p...
xf_FAILM	0	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		option matrix failure
xf_FAILF	0.0	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		option fiber failure
fd_BC	2.0	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		plastic equivalent failure strain (...)

<< < New Edit Save Cancel > >>

- classifying by mechanical behavior
- description



4a impetus – new software features

Material model – failure models



Test Test database Measurement Report Measurement curves Viewer a(t) v(t) s(t) F(t) F(s) E(t) sig(eps) epspnt(eps) Parameter

160722_041 Material Designvariables Layers

Model settings

Material

Idealization

Material behaviour

Material source Implemented

Elasticity Linear isotropic elastic

Plasticity Yes

Failure/Damage Damage

Material card *MAT_SAMP-1 (*MAT_187)

Materialcardcase pressure dependent (Raghava)

Damage/Failurecase **Add Erosion DIEM**

Materialcard id None

Density plastic strain

Plasticity Add Erosion

Function (Hardening, Elastic curve form)

Curve 1 Add Erosion DIEM

Curve 2 Add Erosion GISSMO

Scale curve 1 scale curve 1

Strain range upto 1

Sampling points 100

Bias factor 10

Strain rate dependency Table

Strain rate dependency Johnson Cook

Fracture Damage

Ductile Damage Settings 4a picewise linear

lower triax value -0.99

upper triax value 0.99

step size triax 0.33

Shear Damage Settings None

FLC Damage Settings None

Strainrate Settings Johnson Cook

Postfracture Fracture Energy (TRIAx)

Loadcases

Results

Test Test database Measurement Report Measurement curves Viewer a(t) v(t) s(t) F(t) F(s) E(t) sig(eps) epspnt(eps) Parameter

160722_041 Material Designvariables Layers

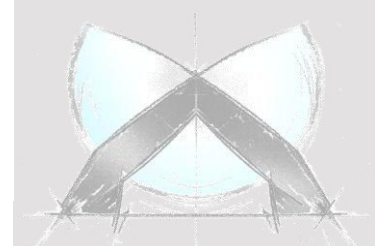
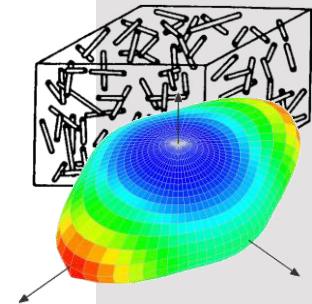
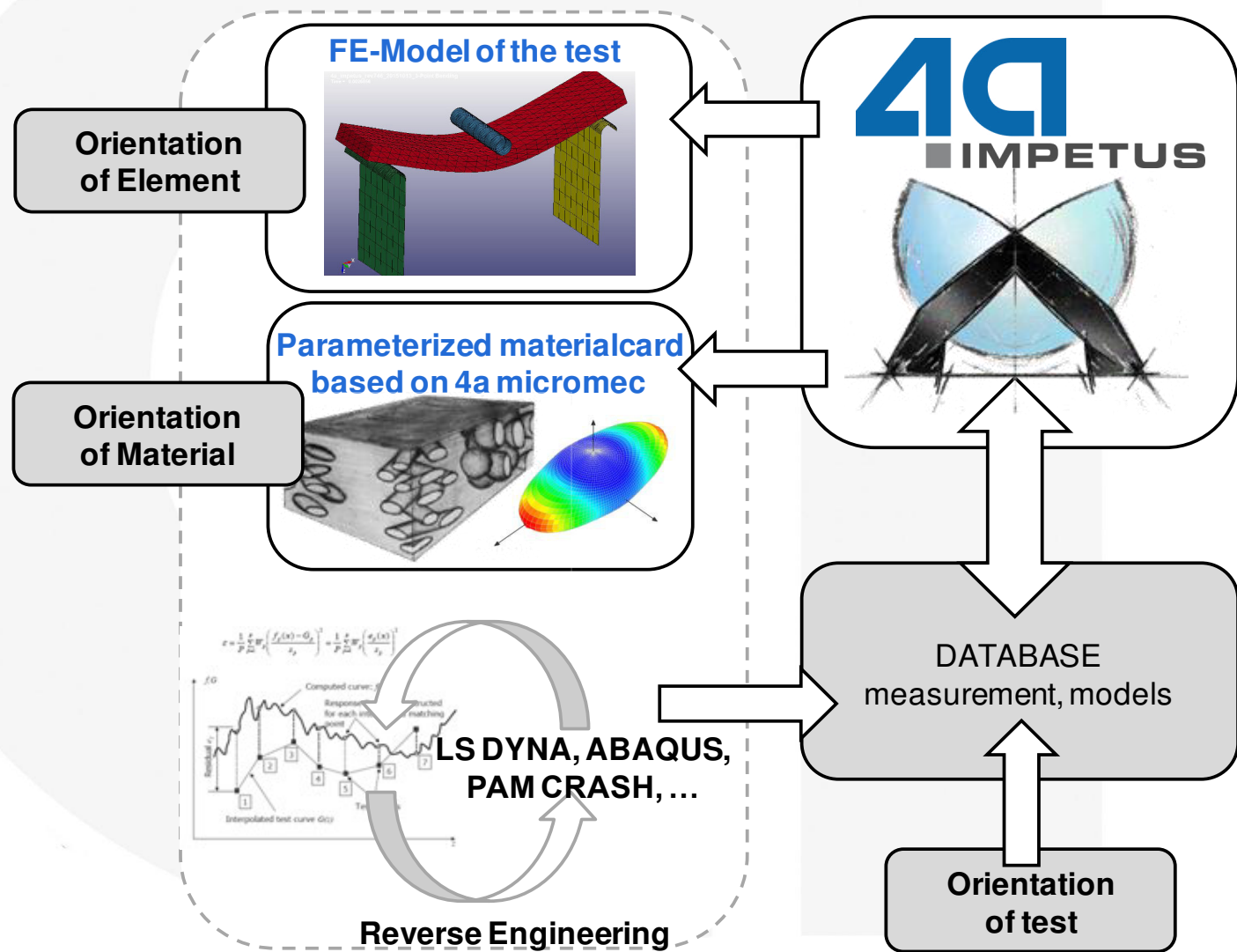
Name	Start	const...	from	to	Variance	Condi...	Descri...
▼ GroupName:							
▼ GroupName: 10_elasticity							
▼ GroupName: 20_yield							
▼ GroupName: 21_hardening							
▼ GroupName: 31_strainrate							
▶ ▲ GroupName: 51_failure							
xf_NUM...	0.75	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		Num...
fd_BC	2.0	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		plastic...
fd_C	2.0	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		plastic...
fd_SHC	2.0	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		plastic...
fd_SHT	0.1	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		plastic...
fd_T	0.1	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		plastic...
fd_BT	0.2	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		plastic...
▲ GroupName: 52_failure							
fv_scale	0.0	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		
fv_epspkt	0.001	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		
fv_esp...	1000.0	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		
▲ GroupName: 53_postfailure							
pf_QBC	0.05	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		
pf_QC	0.05	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		
pf_QSHC	0.05	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		
pf_QSHT	0.05	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		
pf_QT	0.05	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		
pf_QBT	0.05	<input checked="" type="checkbox"/>	(NULL)	(NULL)	(NULL)		

* Click here to add a new row

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4a impetus – new software features

Anisotropy – Composites



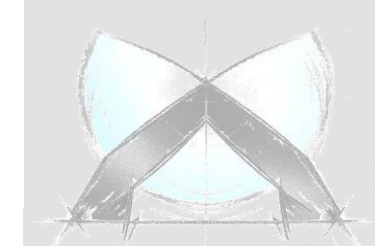
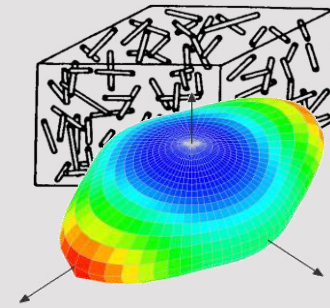
4a impetus – new software features

Anisotropy – Composites

160223_006 Material Designvariablen Layers

Strain rate dependency	Table	
Strain rate dependency	Johnson Cook	
Micromec	User defined	
Matrix		
Density of the matrix	900	} matrix data
E-Modulus	1500	
Poisson's ratio	0.3	
Yield strength	15	
Strength at Break	17	
Failure strain	0.05	
Fiber		
Fillerlength	1000	} filler data
Fillerdiameter	20	
Phi or Psi	φ	
Phi	12.9	
Psi	30.1	
Fillermaterial	E-Glas	
Orientation		
Fillerorientationtype	CA lin. OF	} orientation data
Fillerorientationvalue 1	0.6	
Fillerorientationvalue 2	0.33	

Composite Density	1126	[g/dm ³]
c_C11	6172	[MPa]
c_C12	1808	[MPa]
c_C13	1231	[MPa]
c_C14	0	[MPa]
c_C15	0	[MPa]
c_C16	0	[MPa]
c_C22	4135	[MPa]
c_C23	1181	[MPa]
c_C24	0	[MPa]
c_C25	0	[MPa]
c_C26	0	[MPa]
c_C33	2616	[MPa]
c_C34	0	[MPa]
c_C35	0	[MPa]
c_C36	0	[MPa]
c_C44	1554	[MPa]
c_C45	0	[MPa]
c_C46	0	[MPa]
c_C55	888.6	[MPa]
c_C56	0	[MPa]
c_C66	957.5	[MPa]
y_r00	1	[1]
y_r45	0.5105	[1]
y_r90	0.2665	[1]
y_scalematrix0	3.076	[1]

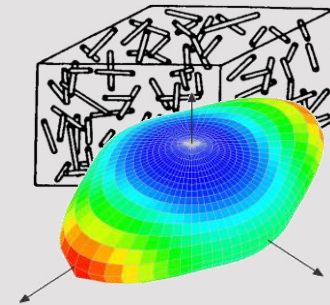


4a impetus – new software features

Anisotropy – Composites

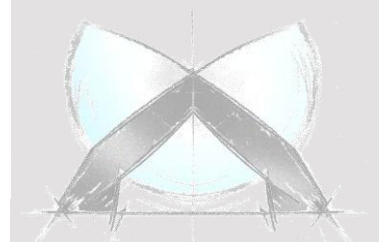
Name	Start	const...	Description
GroupName: 10_elasticity			
c_C11	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 11
c_C12	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 12
c_C13	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 13
c_C14	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 14
c_C15	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 15
c_C16	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 16
c_C22	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 23
c_C23	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 23
c_C24	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 24
c_C25	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 25
c_C26	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 26
c_C33	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 33
c_C34	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 34
c_C35	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 35
c_C36	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 36
c_C44	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 44
c_C45	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 45
c_C46	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 46
c_C55	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 55
c_C56	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 56
c_C66	MMEC	<input checked="" type="checkbox"/>	constitutive matrix 66

Name	Start	const...	Description
GroupName: 10_elasticity			
GroupName: 20_yield			
y_0	90	<input type="checkbox"/>	yield stress
y_scale...	MMEC	<input checked="" type="checkbox"/>	yield scale 11 direction
y_r00	MMEC	<input checked="" type="checkbox"/>	yield hill anisotropy ratio 0°
y_r45	MMEC	<input checked="" type="checkbox"/>	yield hill anisotropy ratio 45°
y_r90	MMEC	<input checked="" type="checkbox"/>	yield hill anisotropy ratio 90°
GroupName: 21_hardening			
h_ET	50	<input type="checkbox"/>	
h_y	90	<input checked="" type="checkbox"/>	
GroupName: 31_strainrate			
v_epspkt	0.01	<input checked="" type="checkbox"/>	initial strain rate threshold
v_p	15	<input type="checkbox"/>	strain rate scale (1/vp)
GroupName: 51_failure			
xf_NUM...	0.75	<input checked="" type="checkbox"/>	Number of failed integration points prior to



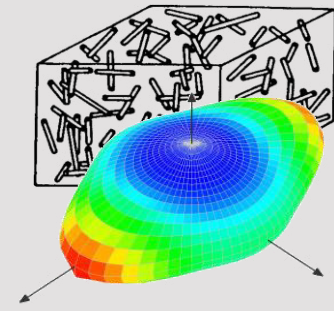
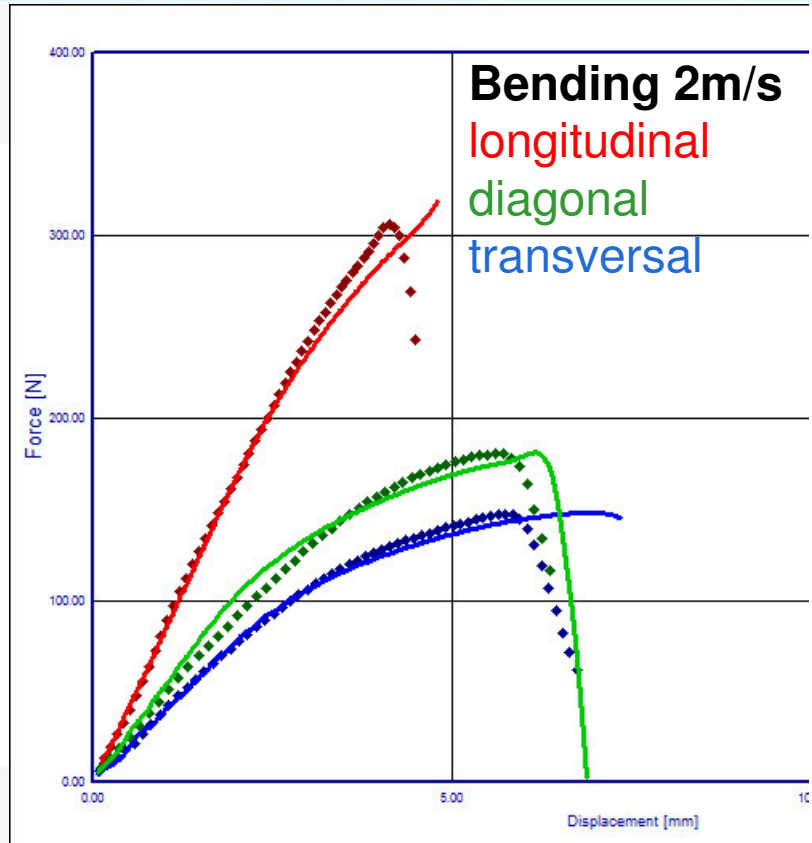
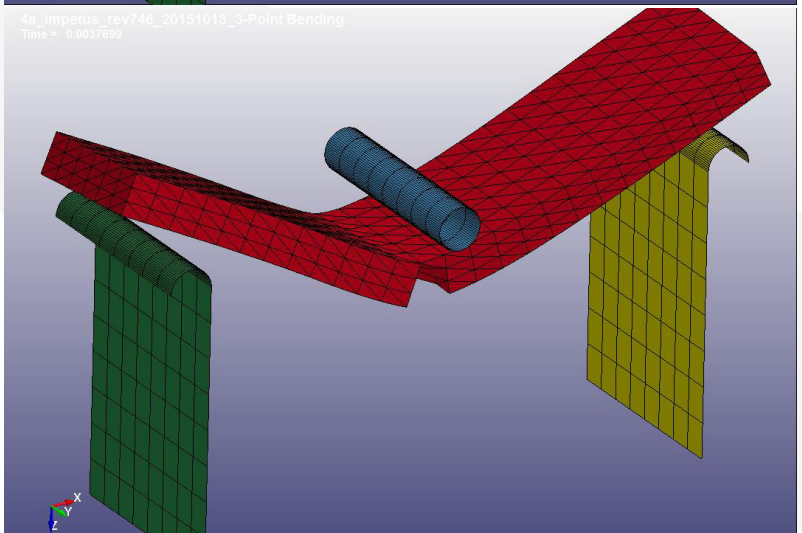
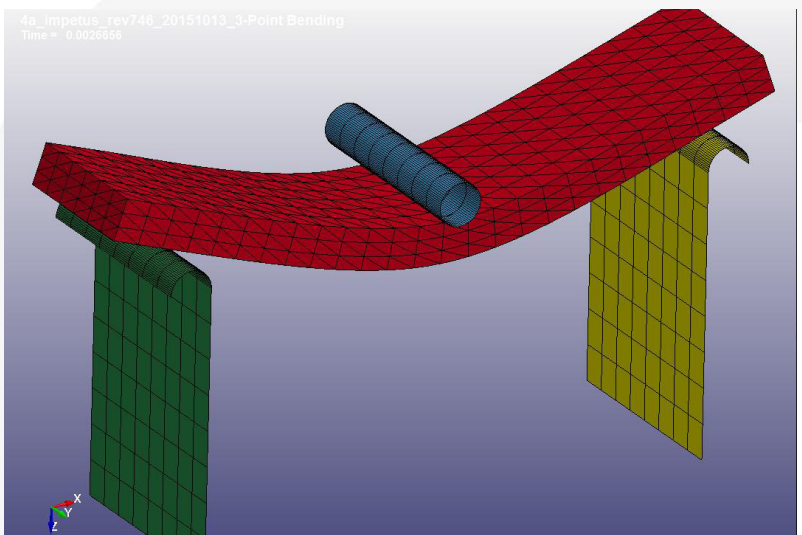
e.g.: 30 design variables for
***MAT_157**

MMEC – design variable calculated by micro mechanic model
Less free design variables left for material parameter identification

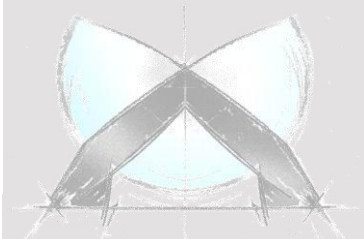


4a impetus – new software features

Anisotropy – Composites



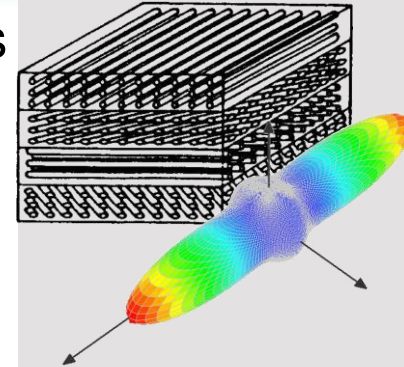
[P. Reithofer et al - Material characterization of composites using micro mechanic models as key enabler, CAE Grand Challenge 2016, Hanau]



4a impetus – new software features

Anisotropy – Composites

- Additional possibility **to define LAYUP** in 4a impetus for composites
- **Sample orientation** from test database



Parameter model*

160708_001 Material Designvariablen Layers

Additional settings

Friction coefficient	0.1
Contactthickness	1
Young's Modulus of support / fin	210000
Density of support / fin	7800
Time scaling	1
Number of element layers	9
Write part/section	Composite
Scale the thickness to the measure	Yes
Element type	16: Fully integrated shell ele
User defined parameter	0
Shell thickness update	no change in thickness

Material behaviour

Material source Implemented

Elasticity Not isotropic elastic

Plasticity Not selected

Failure/Damage Not selected

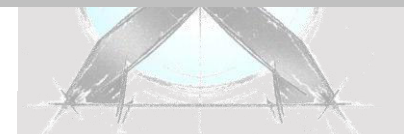
Material card *MAT_COMPOSITE_DAMAGE (*MAT_022)

Materialcardcase 7500_MAT22

Parameter model*

160708_001 Material Designvariablen Layers

MaterialID	Thickness	angle
1000000	0.2	0
1000000	0.2	90
1000000	0.2	0
1000000	0.2	90
1000000	0.2	90
1000000	0.2	0
1000000	0.2	90
1000000	0.2	90
1000000	0.2	0



4a impetus – new hardware features

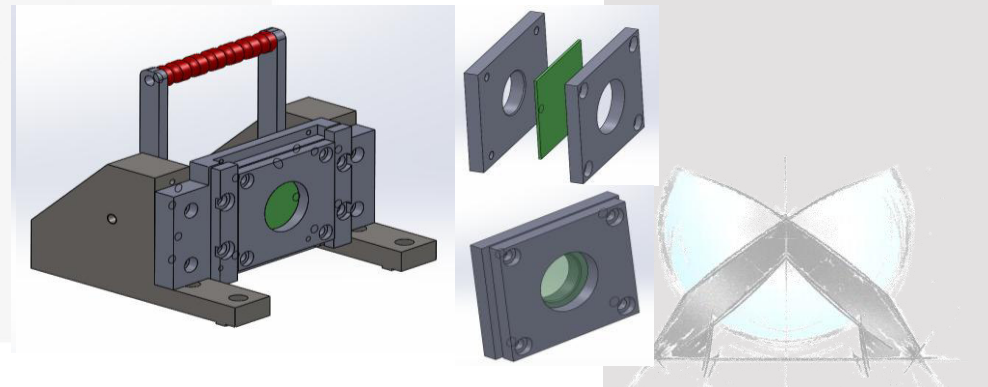
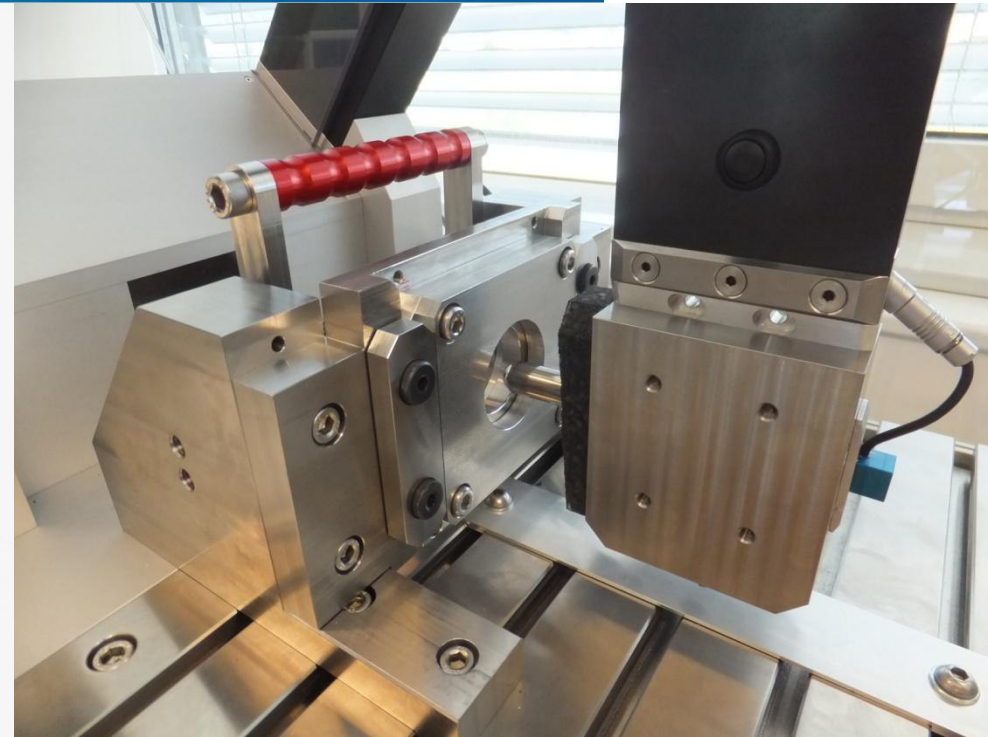
New pendulum arm

- Dynamic 3-point-bending **tests of composite materials** or puncture tests of thermoplastic materials
- Usable up to an **impact energy of 50 J**
- Vibration reduced pendulum arm made of **carbon**, aluminum and steel alloy
- Plugable acceleration sensors
- Mounting of additional masses possible (mass: 1 – 4 kg)



New puncture test

- Loosely based on DIN EN ISO 6603-2
- Easy mounting on 4a impetus
- Various inserts and impactor diameter
- Additional masses possible
- Quick change of inserts → possibility for testing at **low or high temperatures**
- Maximum energy: 50 J
- Investigation of **flow behavior and failure under biaxial load**

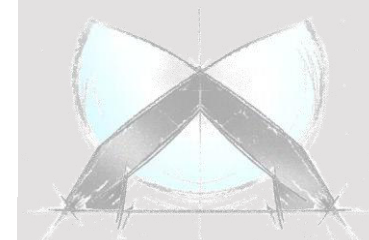
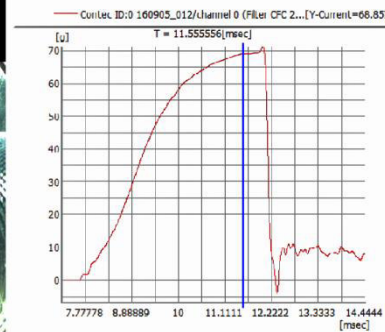
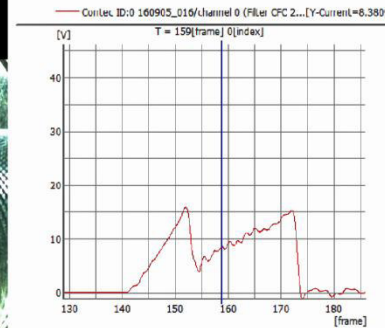
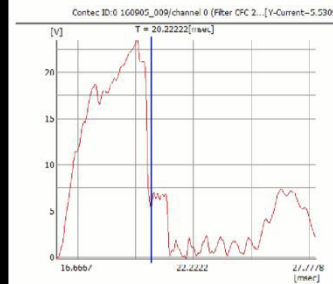


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4a impetus – new hardware features

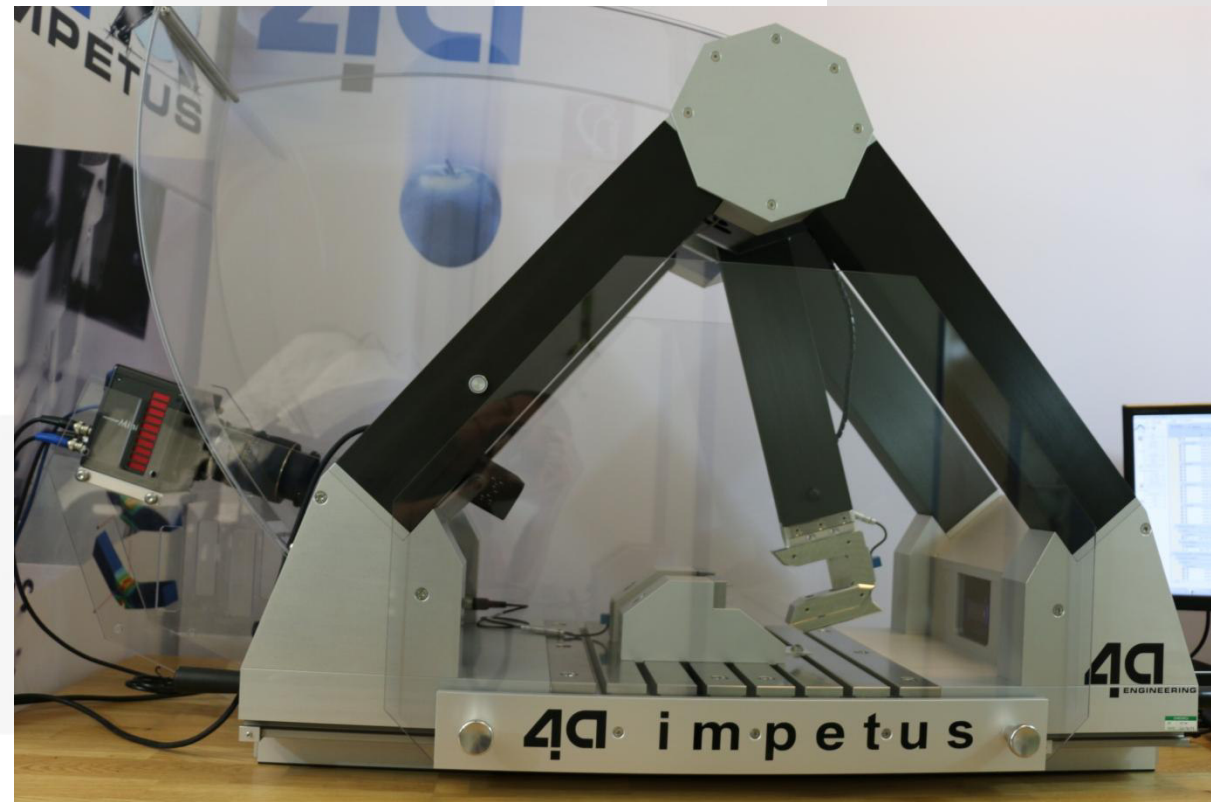
New puncture test

- Test results:



High-speed camera

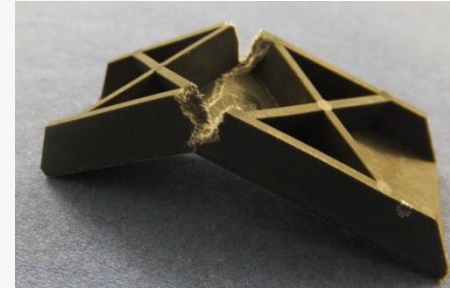
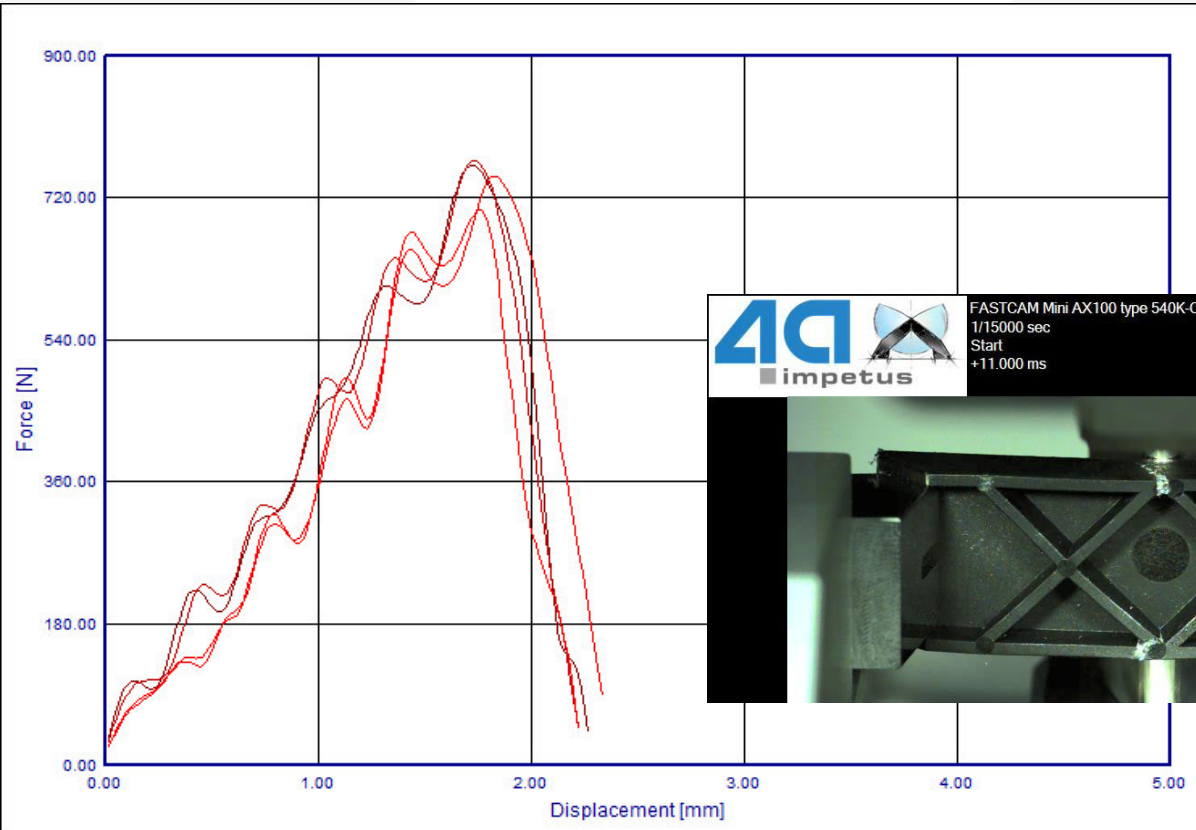
- **Visualization of dynamic behavior** of the material during test (crack initiation and propagation)
- Easy view, different angles possible
- Trigger signal from 4a impetus
→ **synchronizing**



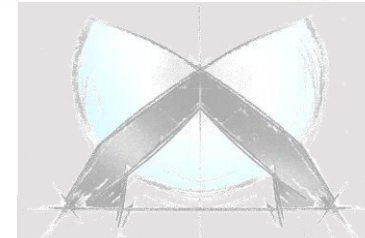
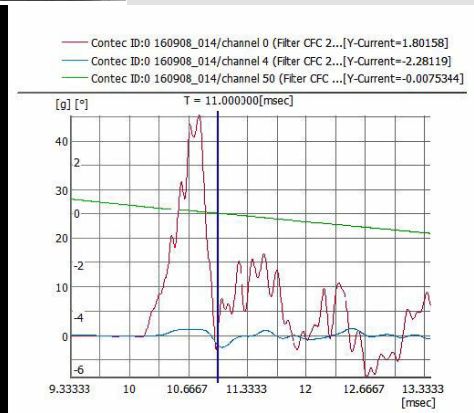
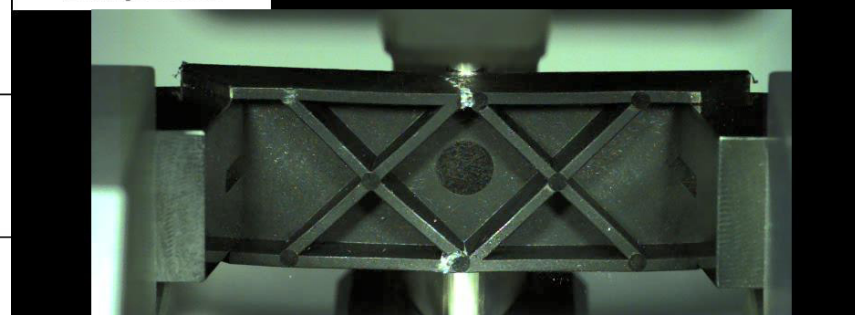
4a impetus – new hardware features

High-speed camera

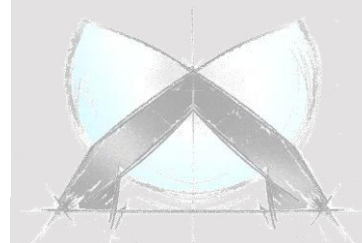
- Example: XX-rib, PP LGF30, dynamic 3-point bending @ 3 mps force-displacement curves by 4a impetus



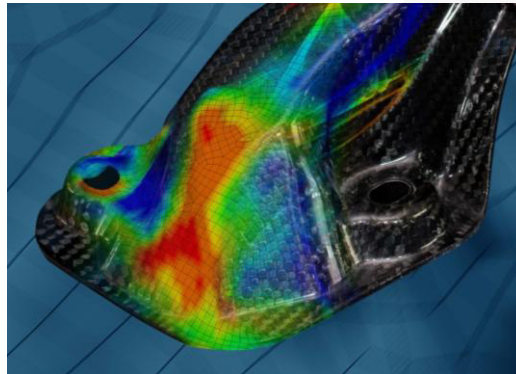
FASTCAM Mini AX100 type 540K-C-16GB
15000 fps
1/15000 sec
Start
+11.000 ms
768 x 336
frame : 165
Date : 2016/9/8



- **Complex material models**
 - accurate description of plastics and composites
- **Appropriate test methods**
 - get access to the material model parameters
 - time and cost efficient
- **MPIP - Material Parameter Identification Process**
 - to fit the material model parameters
 - time and cost efficient
- **Continuous improvements in 4a impetus** hard- and software
 - easy, time & cost efficient
 - accurate **validated material cards**



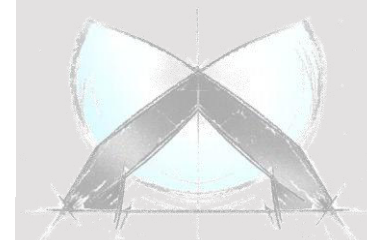
Thank you for your attention!



14th **4a**
TECHNOLOGIETAG

23.- 24. March 2017
in Schladming, Austria

„Light weight applications & Composites”
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4a impetus (PART 2): innovations – test methods, MAT_SAMP-1, anisotropy, composites and more

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

1 Introduction - Characterizing plastics and composites using 4a impetus

In recent years plastics are substituting other materials mostly to reduce the weight of the part. As they are also carrying the same applied loads it is necessary to consider the deformation behavior (plasticity) as well as damage and failure in the material model. To characterize the dynamic deformation behavior dynamic bending tests on 4a impetus (fig. 1 left) are a cost-efficient alternative or extension compared to standard dynamic test methods. Furthermore many plastic materials have a huge difference in the tension and compression behavior. Consequently a material card generation of simple elastic-viscoplastic material models (e.g. *MAT_024) based on static and dynamic bending tests, which takes both into account, will be near to reality [1].

As a result of the processing unreinforced as well as reinforced plastics have different mechanical properties at the outer surface compared to the inner core. The bending properties (stiffness, failure behavior ...) are usually favorably higher. Due to the stress distribution in bending load cases the outer highly orientated layer carry most of the load compared to the tension case. Engineering judgment based on bending material properties is therefore the better choice.

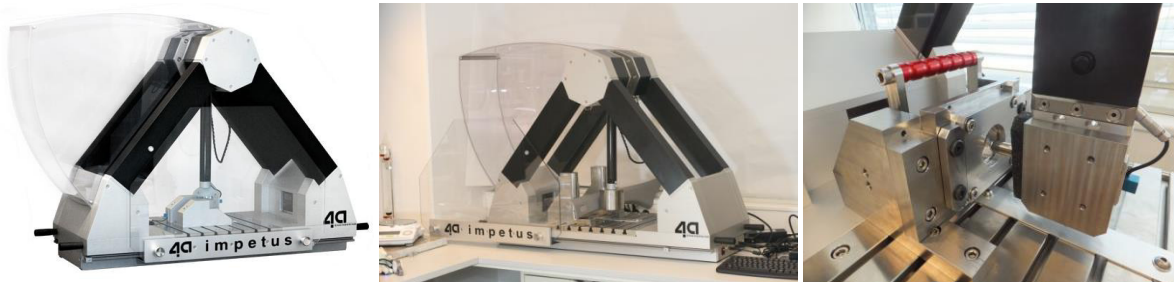


Fig.1: The actual version of 4a impetus (left); component testing in 4a impetus (middle); new puncture test and pendulum arm (right)

Nowadays more detailed material models considering complex yield surfaces (e.g. *MAT_124 or *MAT_187 for plastics), anisotropy (e.g. *MAT_157 or *MAT_215 for reinforced plastics) or complex failure models (e.g. *MAT_ADD_EROSION) are available. The objective is of course a better description of the material behavior [2, 3, 4]. The newest 4a impetus developments regard these needs - always with the focus to offer an efficient material parameter identification process (MPIP).

2 Innovations in 4a impetus - hardware

The design of 4a impetus and the pendulum arm was improved. Now it's possible to test even parts and composite materials up to an impact energy of 50J (fig. 1 middle). To characterize the dynamic behavior and failure under biaxial loading a new puncture test method was designed (fig. 1 right). It also allows testing under low or high temperatures. The implementation of a high-speed-camera (newest accessory kit) allows the visualization of dynamic behavior of the material during test (crack initiation and propagation in detail, see fig. 2).

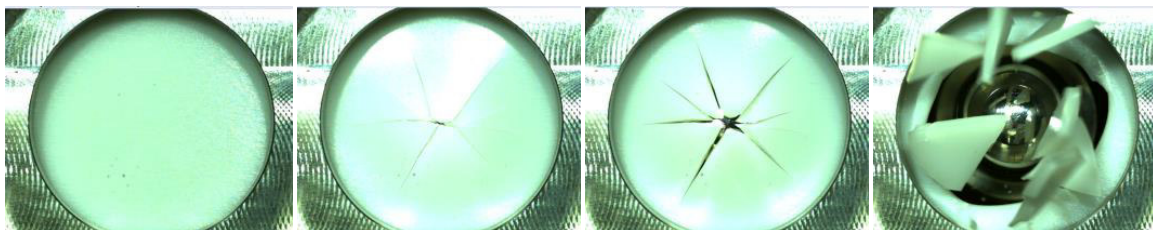


Fig.2: High speed pictures of the dynamic puncture test of a POM at different time steps

3 Innovations in 4a impetus - software

In the presentation many new features will be shown, exemplary two of them are described in this abstract in detail.

The above mentioned complex material models (fig. 3 left) as well as the most common failure models are implemented in 4a impetus GUI. The describing parameters can be directly evaluated in the material parameter identification process. For standard material cards (e.g. *MAT_024) an automated workflow on 3-point-bending-tests was developed and implemented as AUTOFIT process. Within a few clicks and some simulation/optimization time an accurate material card is generated by 4a impetus (fig. 3 right).

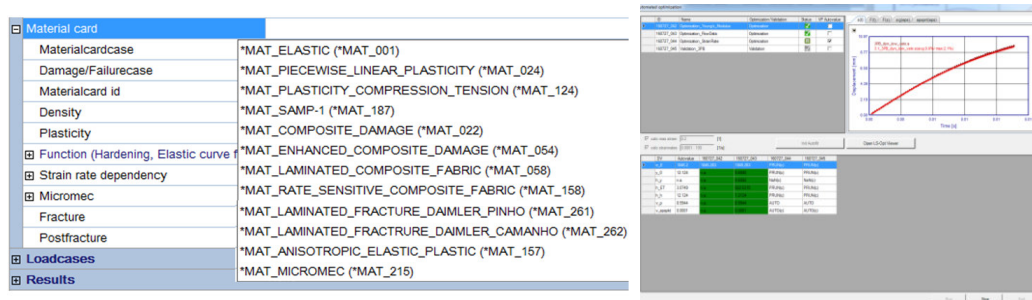


Fig.3: Available LS-DYNA material cards in 4a impetus (left); AUTOFIT process – creating material cards within a few clicks automatically (right)

For fiber reinforced plastics and composites 4a micromec is implemented as library in 4a impetus. 4a micromec is based on the Mori Tanaka Meanfield Theory and allows the user to calculate automatically the thermo elastic mechanical properties of a composite based on the information of the matrix and filler [5]. As a consequence less material parameters have to be determined in the MPIP; so the micro mechanics reduce the effort of testing and material card generation remarkable (fig. 4).

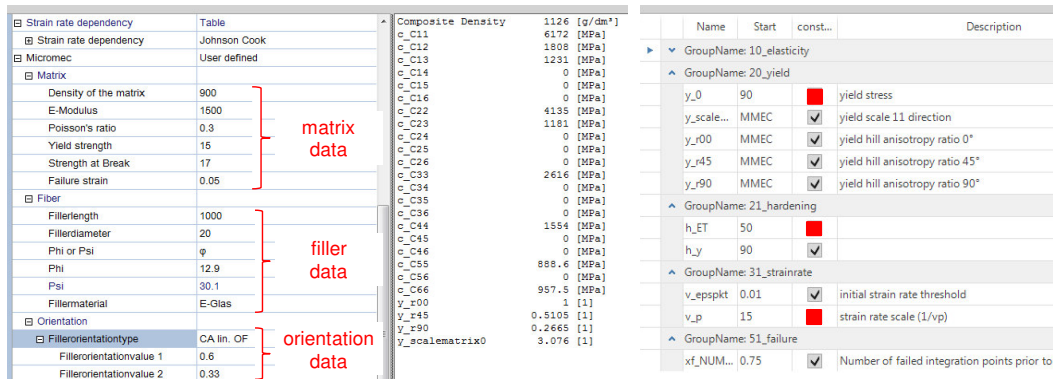


Fig.4: Calculation of the material parameters for *MAT_157 using the 4a micromec library, this reduces the unknown material parameters down to 3 (marked in red) [5]

4 Innovations in 4a impetus - future

In future 4a impetus hardware and software developments will continue to focus on testing and simulation trends. We will work hard to set further trend standards to ensure that the user can generate very easy, quick and cost efficient accurate validated material cards.

5 Literature

- [1] Reithofer, P. et. al: *Dynamic Material Characterization Using 4a impetus*, 29th Regional Conference of the Polymer Processing Society, Graz 2015
- [2] Reithofer, P. et. al: *4a impetus (PART 1): Dynamic material characterization of plastics – development in the past 10 years*, 14. LS-DYNA Anwenderforum, Bamberg 2016
- [3] Fertschej, A. et. al: *Failure models for thermoplastics in LS-DYNA*, 29th Regional Conference of the Polymer Processing Society, Graz 2015
- [4] Staack, H. et. al: *Application oriented failure modeling and characterization for polymers in automotive pedestrian protection*, 8. Complas, Barcelona 2015
- [5] Reithofer, P. et. al: *Material characterization of composites using micro mechanic models as key enabler*, automotive CAE Grand Challenge, Hanau 2016