

Cécile DEMAIN - Confidential

*Simulation Engineer
Part Simulation and Validation Laboratory
POLYAMIDE Group
Lyon Research and Technology Center*

European HyperWorksTechnology Conference 2010

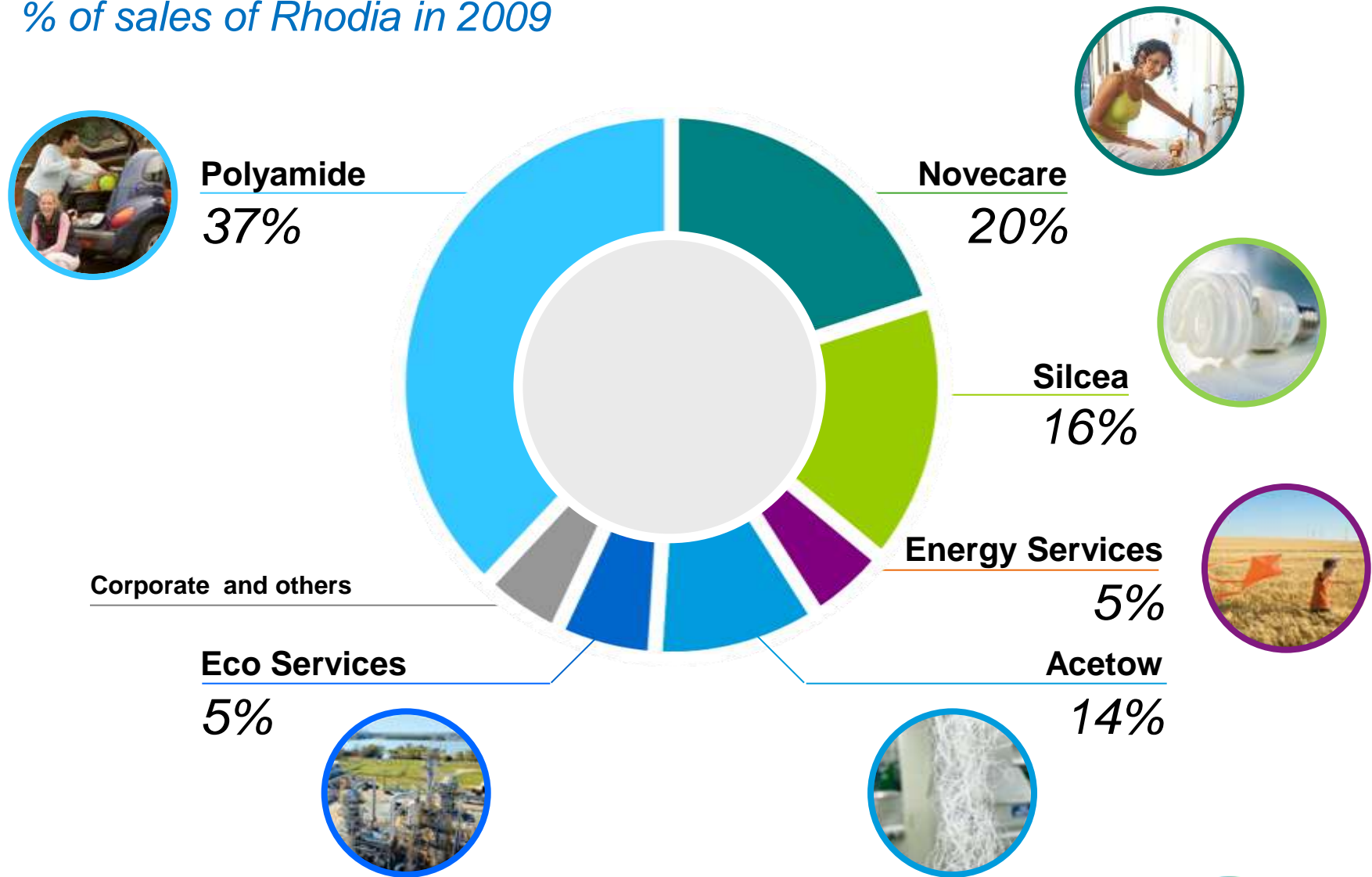
Improving the Prediction of RADIOSS
Calculations with Rhodia Data and Digimat

Summary

- RHODIA Polyamide
- MMI ConfidentDesign
 - Matrix behavior
 - Composite behavior
- Presentation of the MMI Beam
 - Injection & Microstructure
- Correlation using DIGIMAT to RADIOSS
 - Material behavior
 - Model and results
- Conclusions

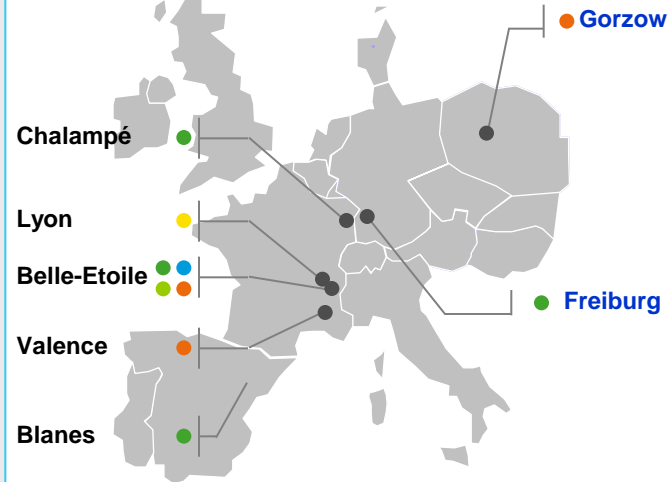
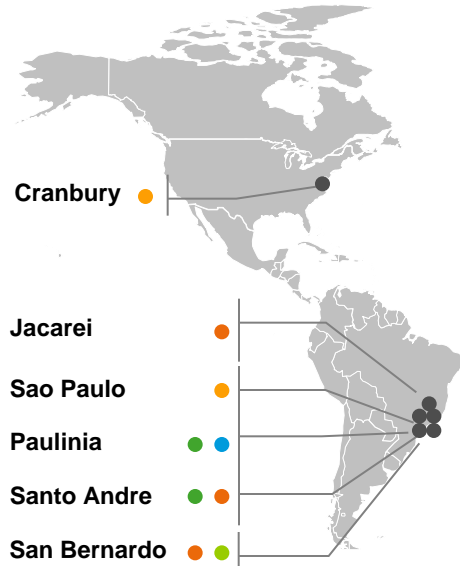
RHODIA : Six enterprises, leaders in their markets

% of sales of Rhodia in 2009



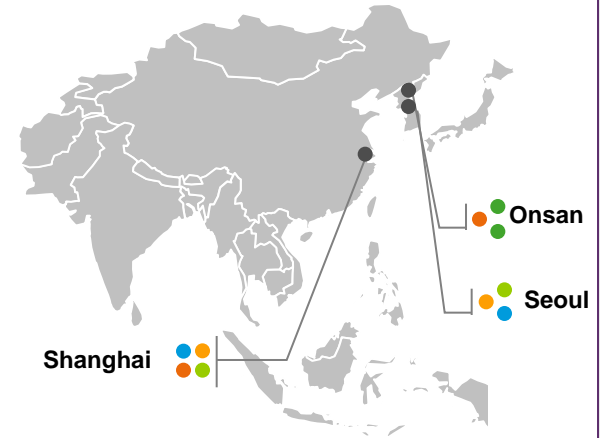
RHODIA Global presence

New polymerization and Phenol capacities in Brazil



Continuous cost improvements in Europe and mature markets

**New capacities in Onsan & Shanghai (polymers and compound)
New R&D center in China**



● Worldwide Headquarter

● Application & Technology Development Centre

● Manufacturing Plant upstream

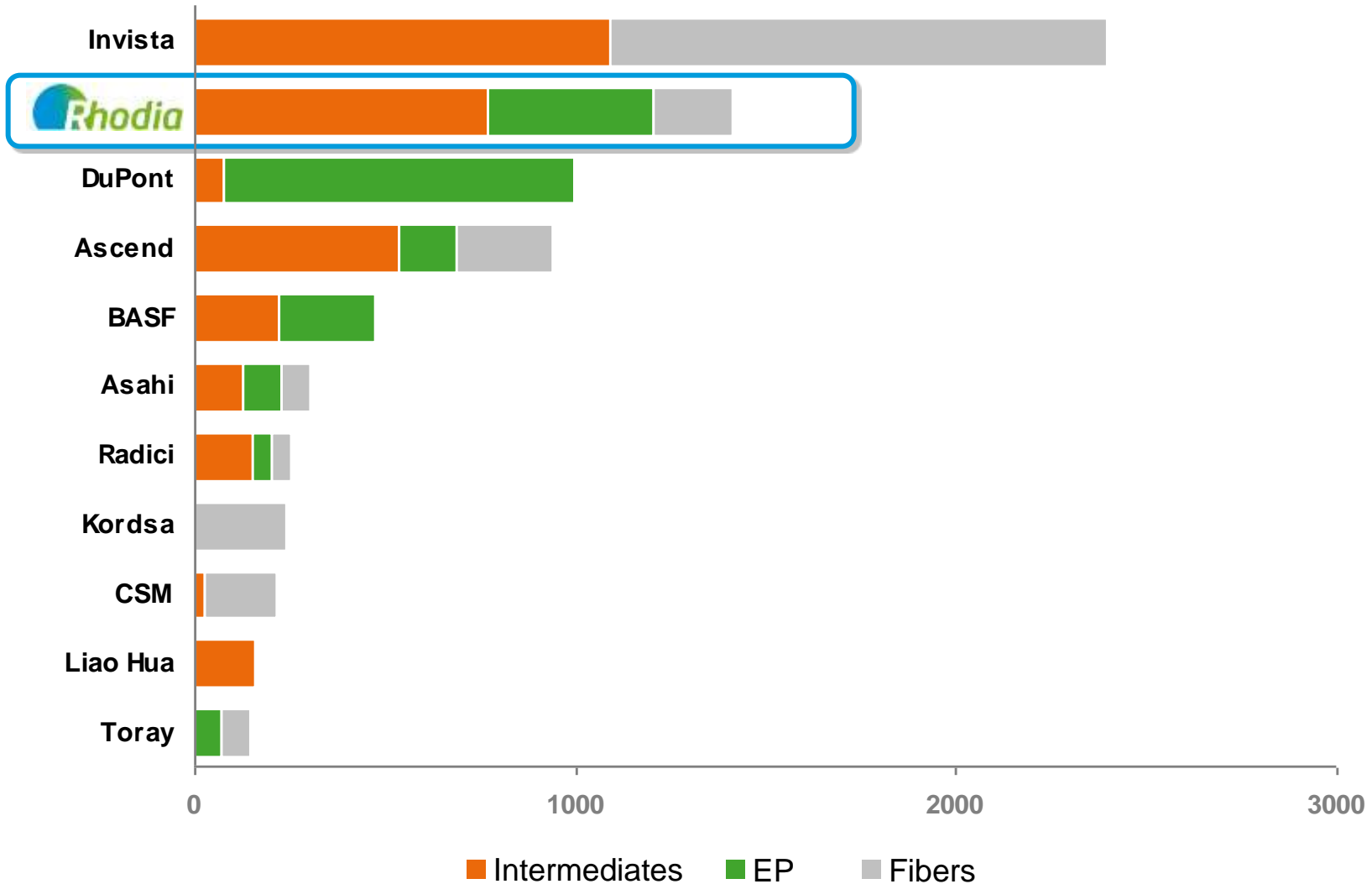
● Regional Headquarter

● R&D Centers

● Manufacturing Plant downstream

RHODIA is the only fully integrated Polyamide 6.6 player with a strong position in Engineering Plastics

2008 Sales* in €m



* Rhodia estimates

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MMI ConfidentialDesign

Powered by DIGIMAT

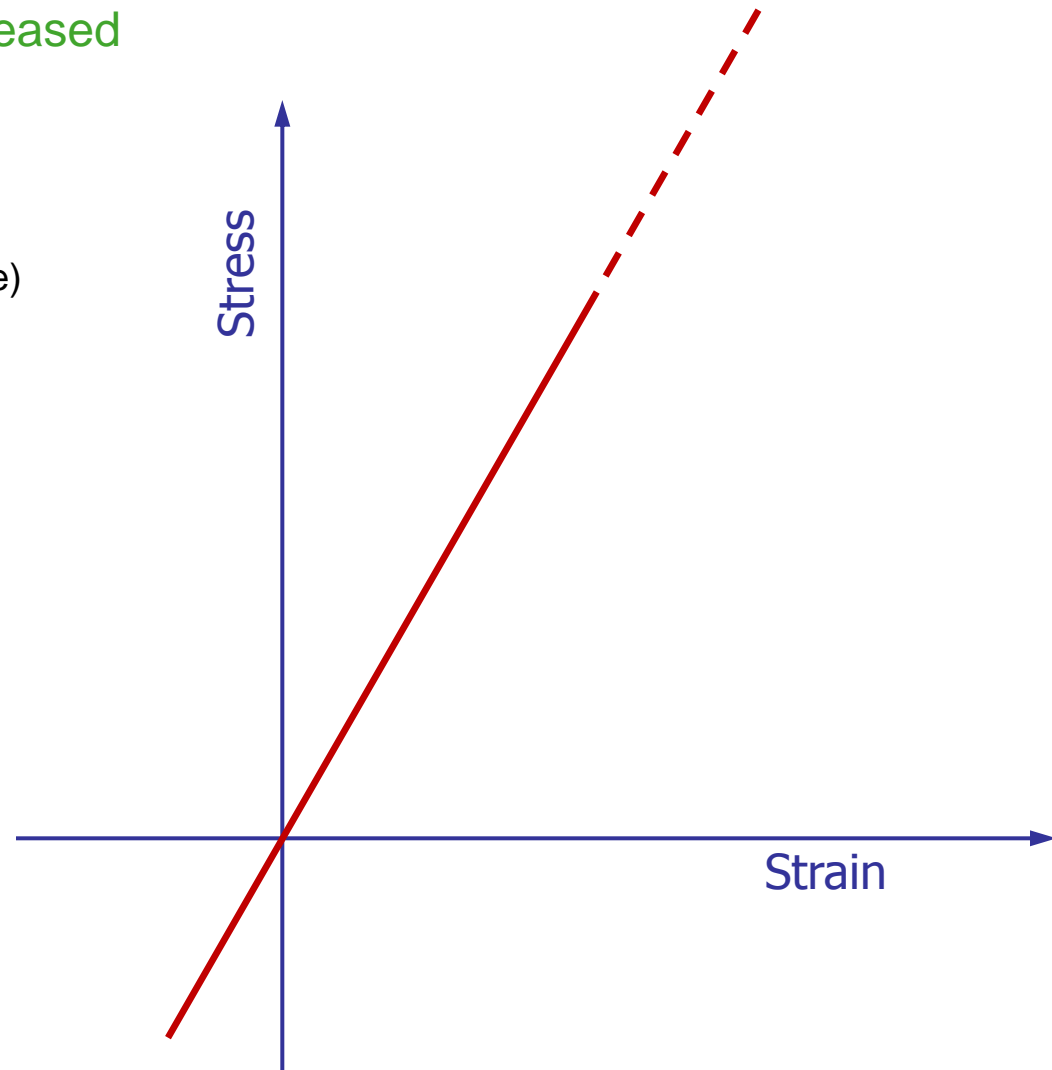
The TOOLS, The DATA and The EXPERTIZE that you need to develop optimal polyamide parts.

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TECHNYL[®] polyamide matrix behavior

- Constitutive models of increased complexity :
 - Elastic
 - =f(temperature, strain rate)



TECHNYL[®] polyamide matrix behavior

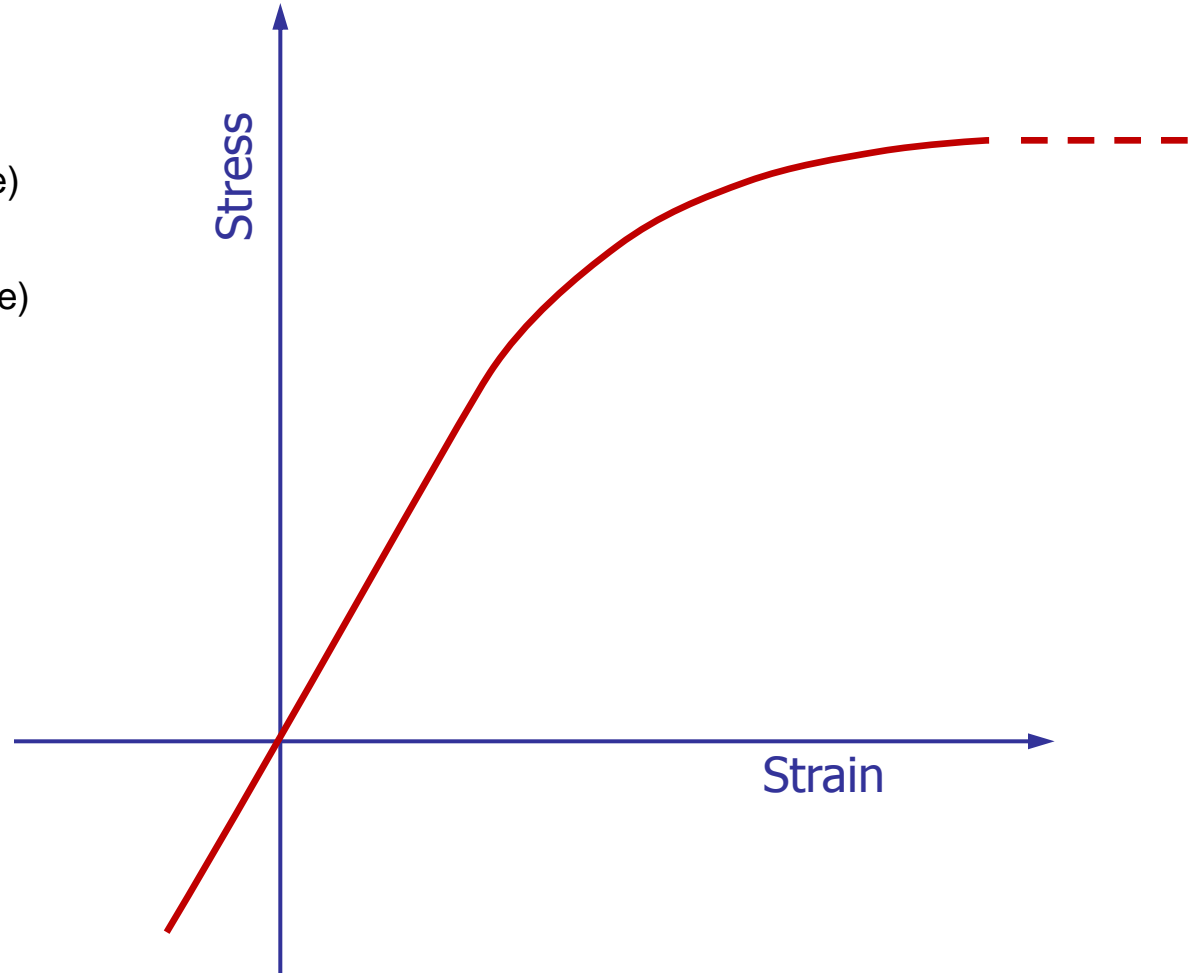
- Constitutive models of increased complexity :

- Elastic

- =f(temperature, strain rate)

- Elastoplastic

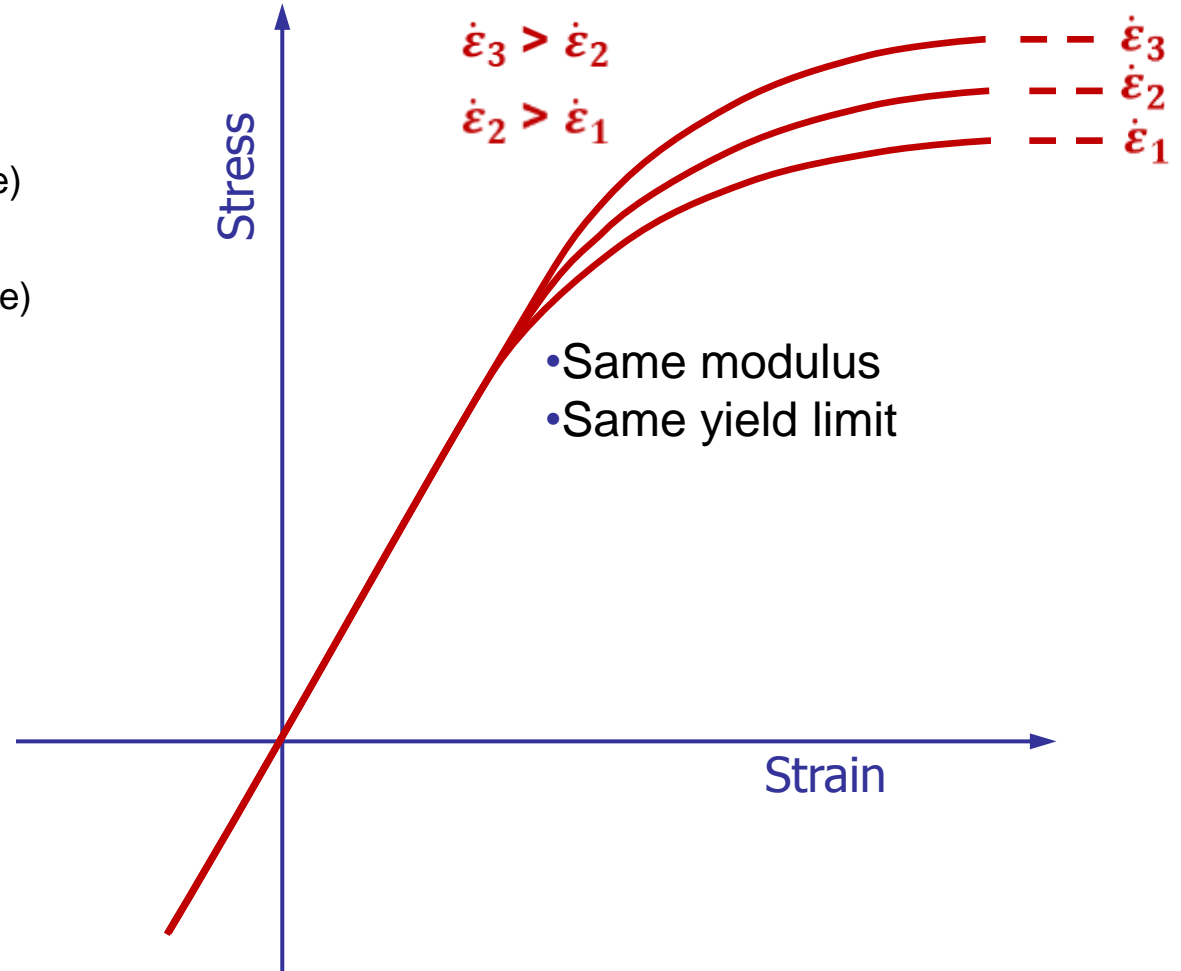
- = f(temperature, strain rate)



TECHNYL[®] polyamide matrix behavior

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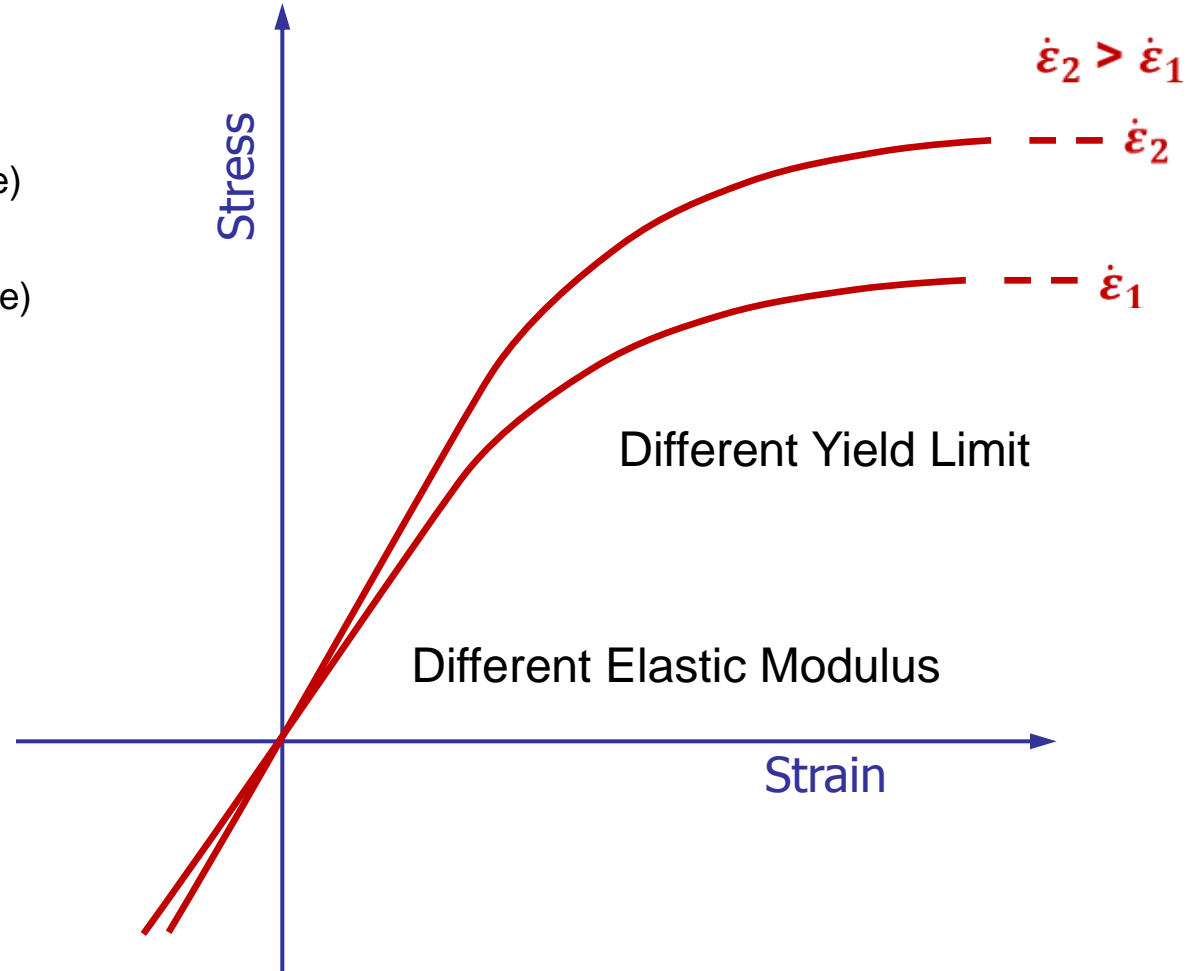
- Elastic
 - =f(temperature, strain rate)
- Elastoplastic
 - = f(temperature, strain rate)
- Elasto-viscoplastic
 - = f(temperature)



TECHNYL[®] polyamide matrix behavior

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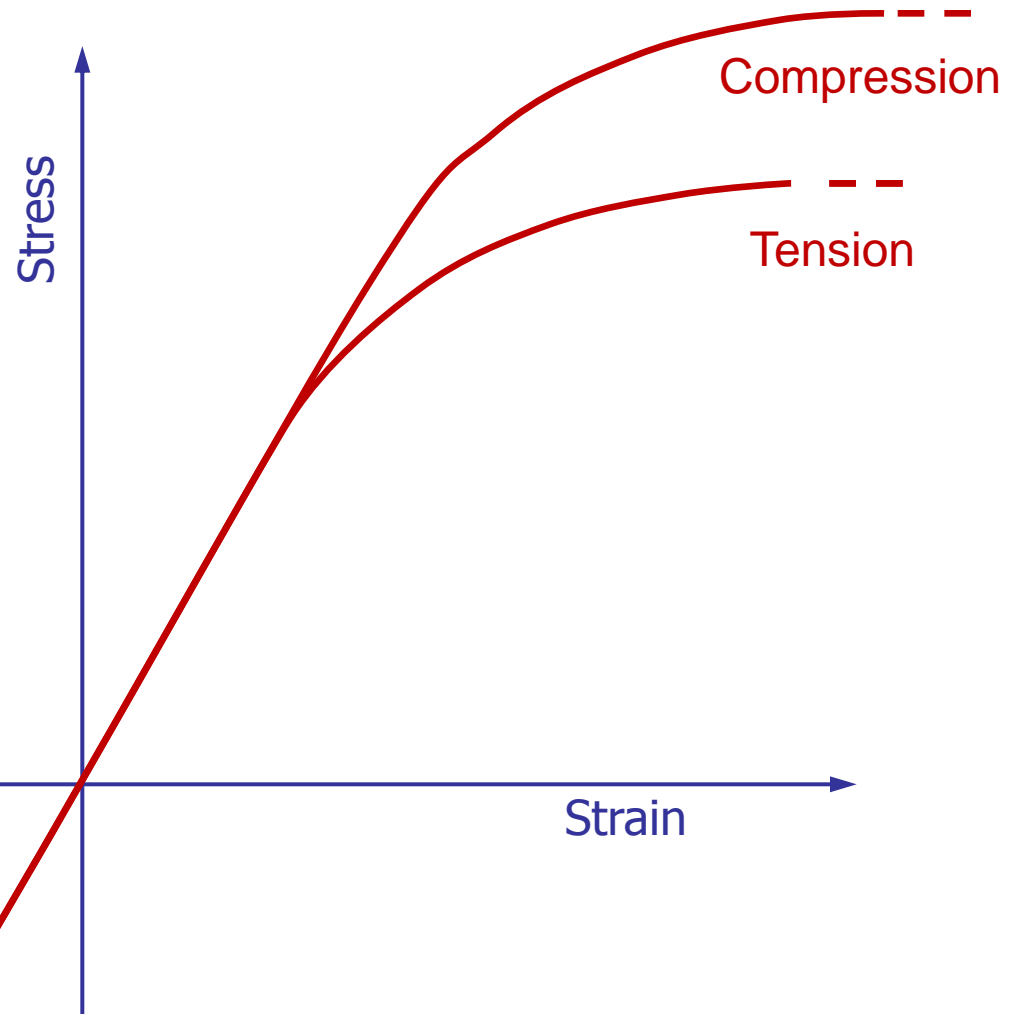
- Elastic
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- Elastoplastic
 - = f(temperature, strain rate)
- Elasto-viscoplastic
 - = f(temperature)
- Viscoelastic-viscoplastic
 - = f(temperature)



TECHNYL[®] polyamide matrix behavior

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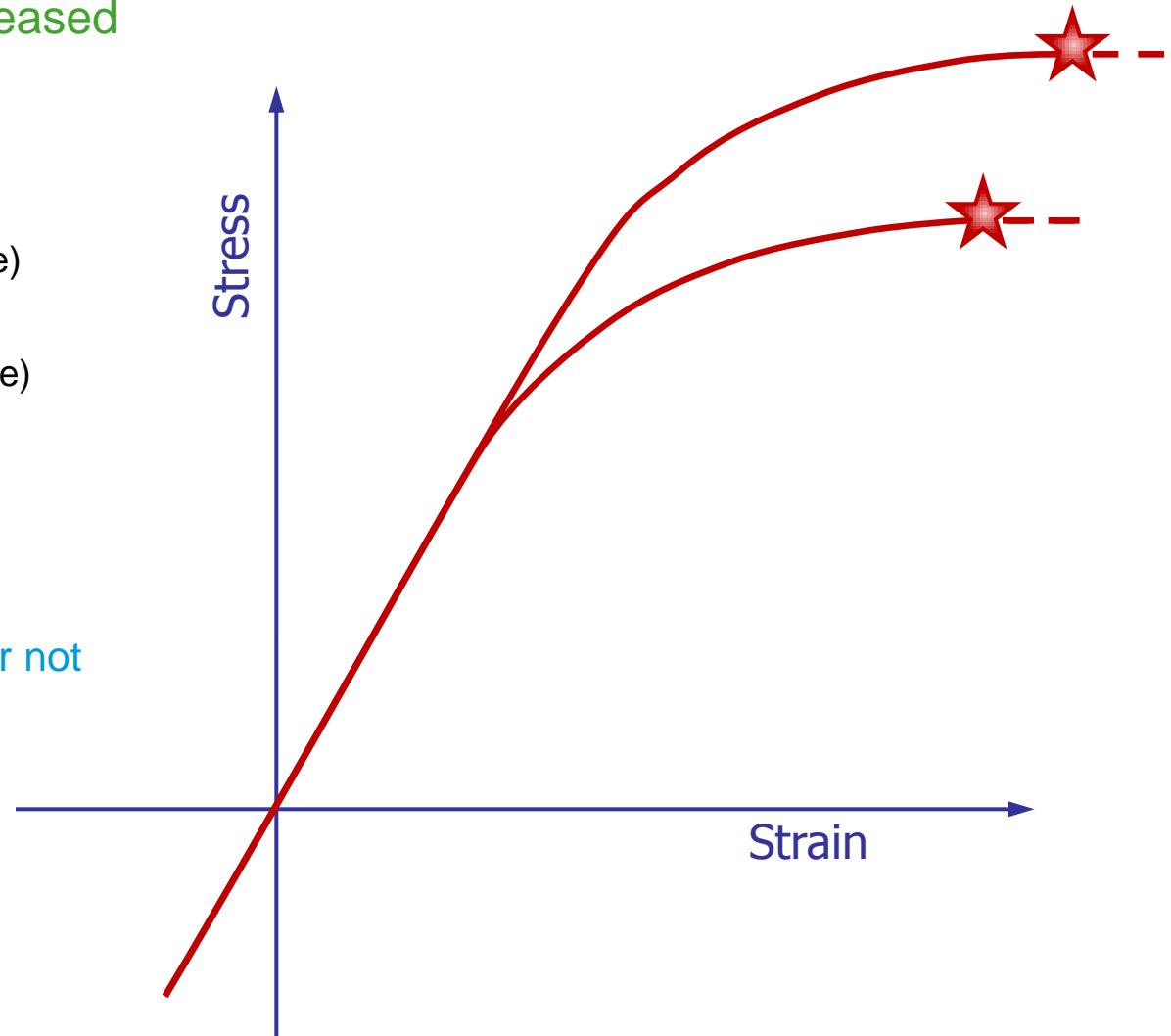
- Elastic
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 - = f(temperature)
- Yield surface dependant or not
 - Tension = compression
 - Tension<>compression



TECHNYL[®] polyamide matrix behavior

- Constitutive models of increased complexity :

- Elastic
 - = f(temperature, strain rate)
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 - = f(temperature)
- Viscoelastic-viscoplastic
 - = f(temperature)
- Yield surface dependant or not
 - Tension = compression
 - Tension <> compression
- Failure criteria

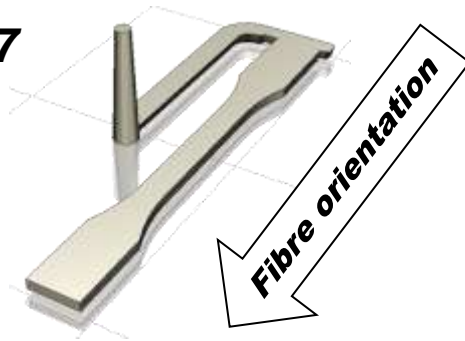


Summary

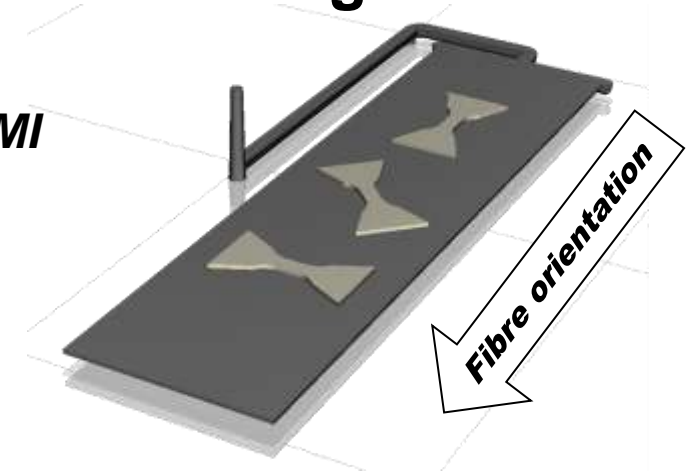
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Better **TECHNYL**[®] composite understanding.

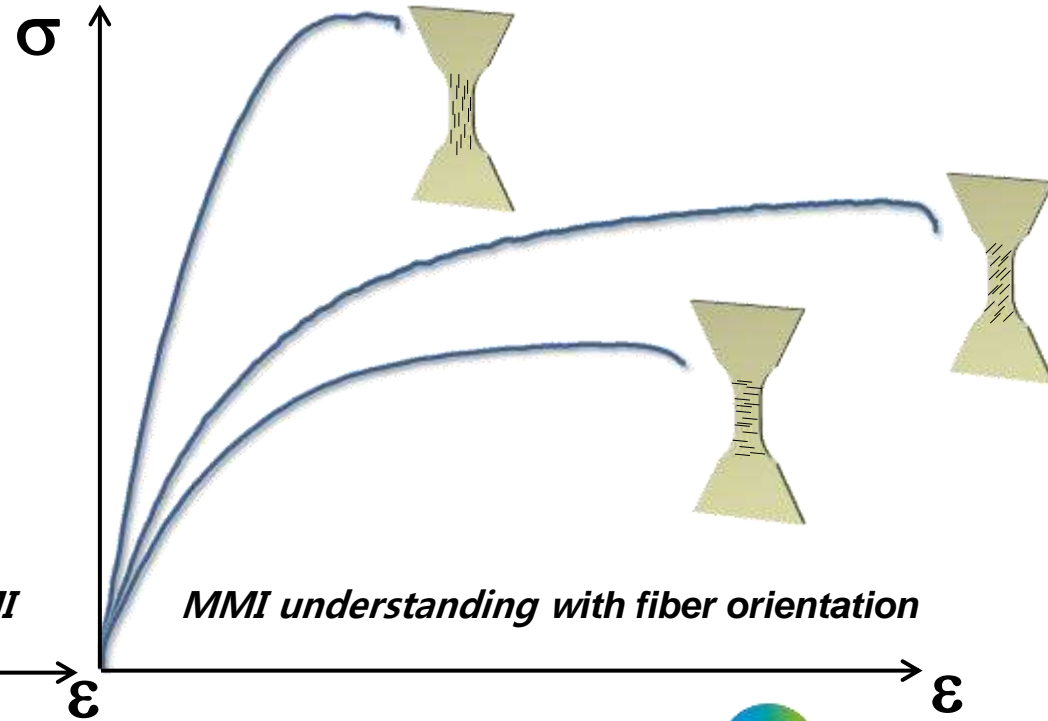
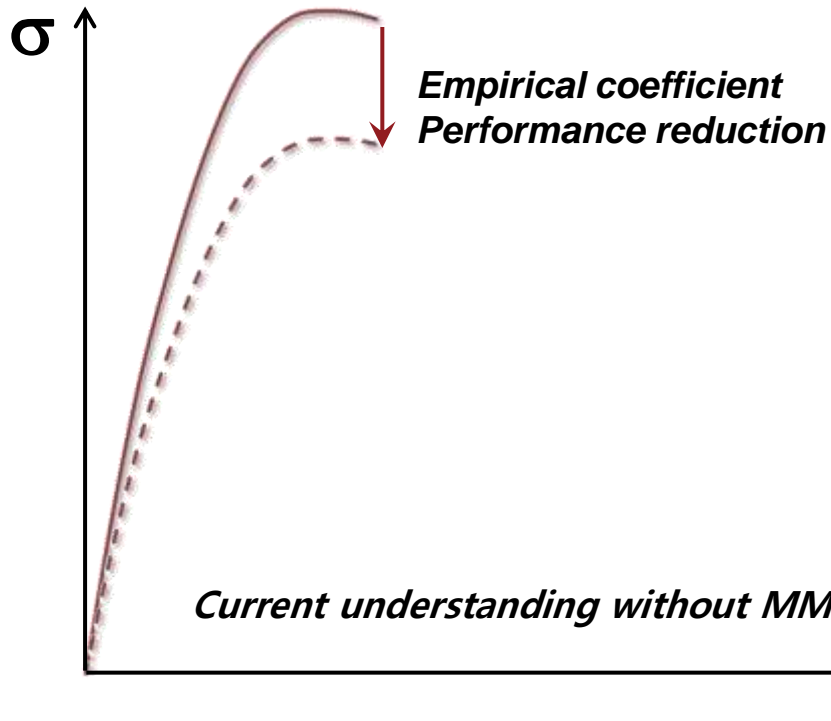
ISO 527



MMI

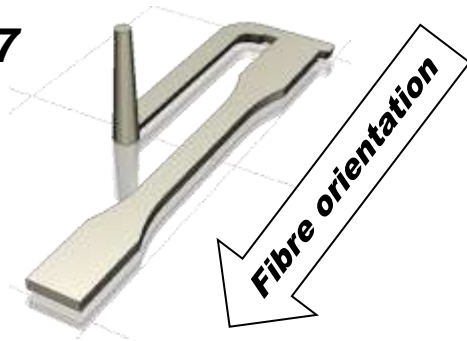


Same material !

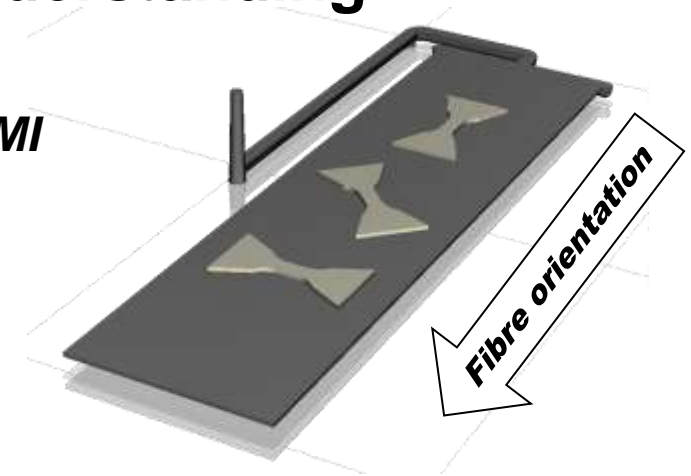


Better **TECHNYL**[®] composite understanding.

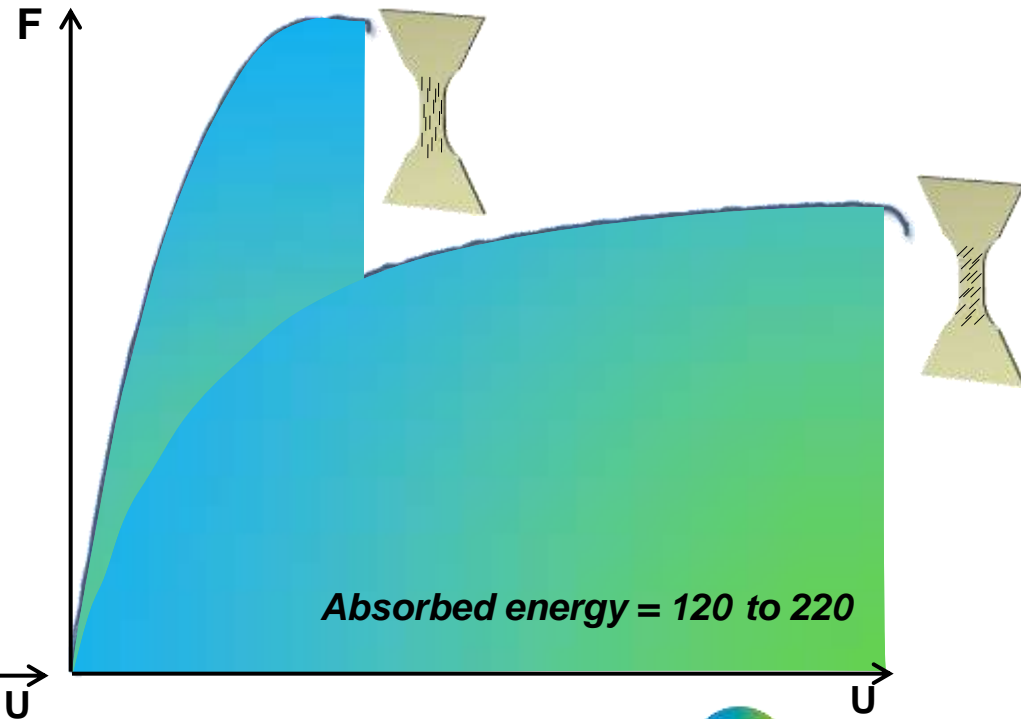
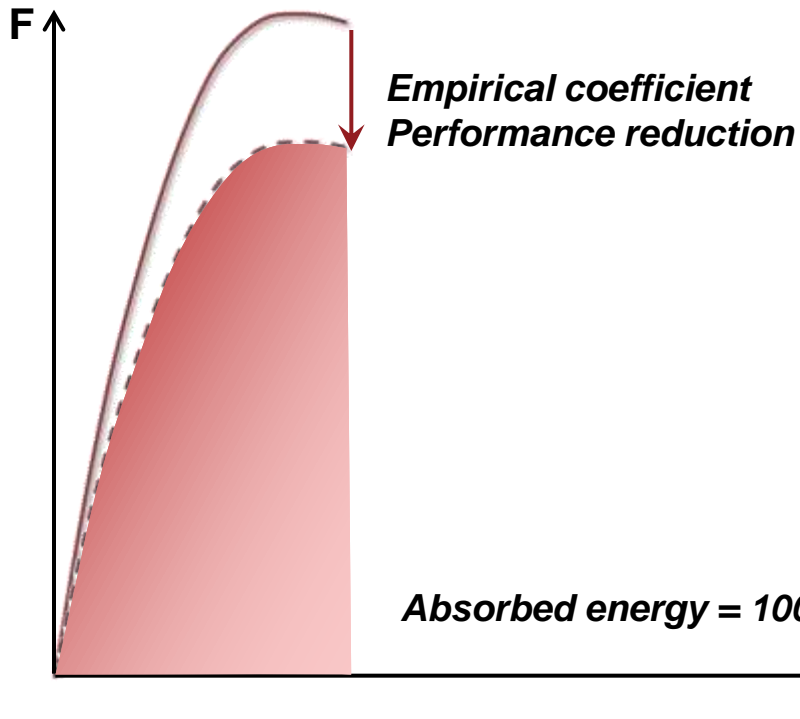
ISO 527



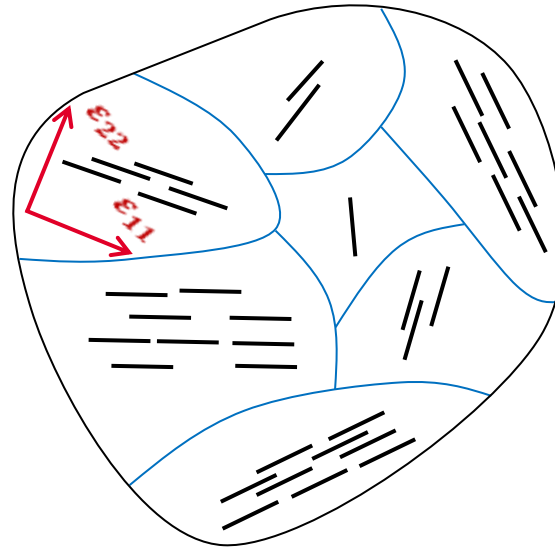
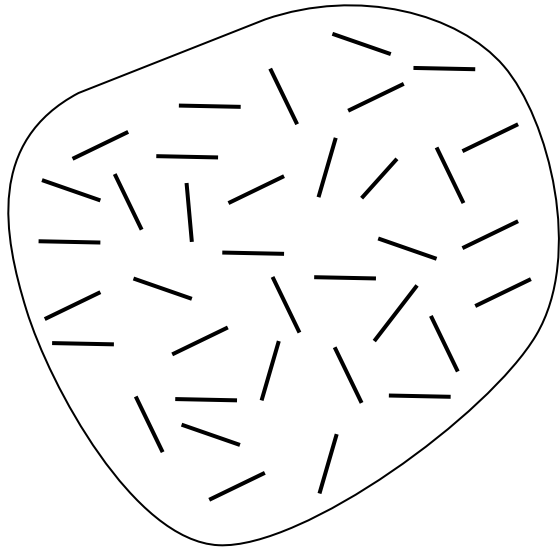
MMI



Same material !



First Pseudo Grain Failure at integration point



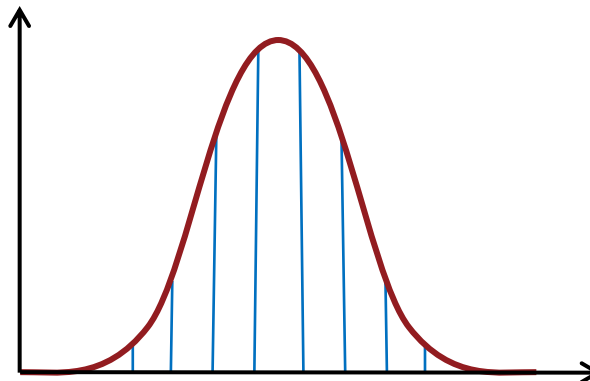
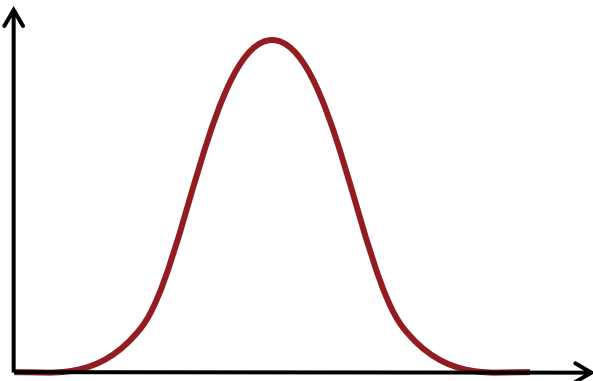
Apply failure indicators on unidirectional composite pseudo grain :

Tsai Hill 2D strain

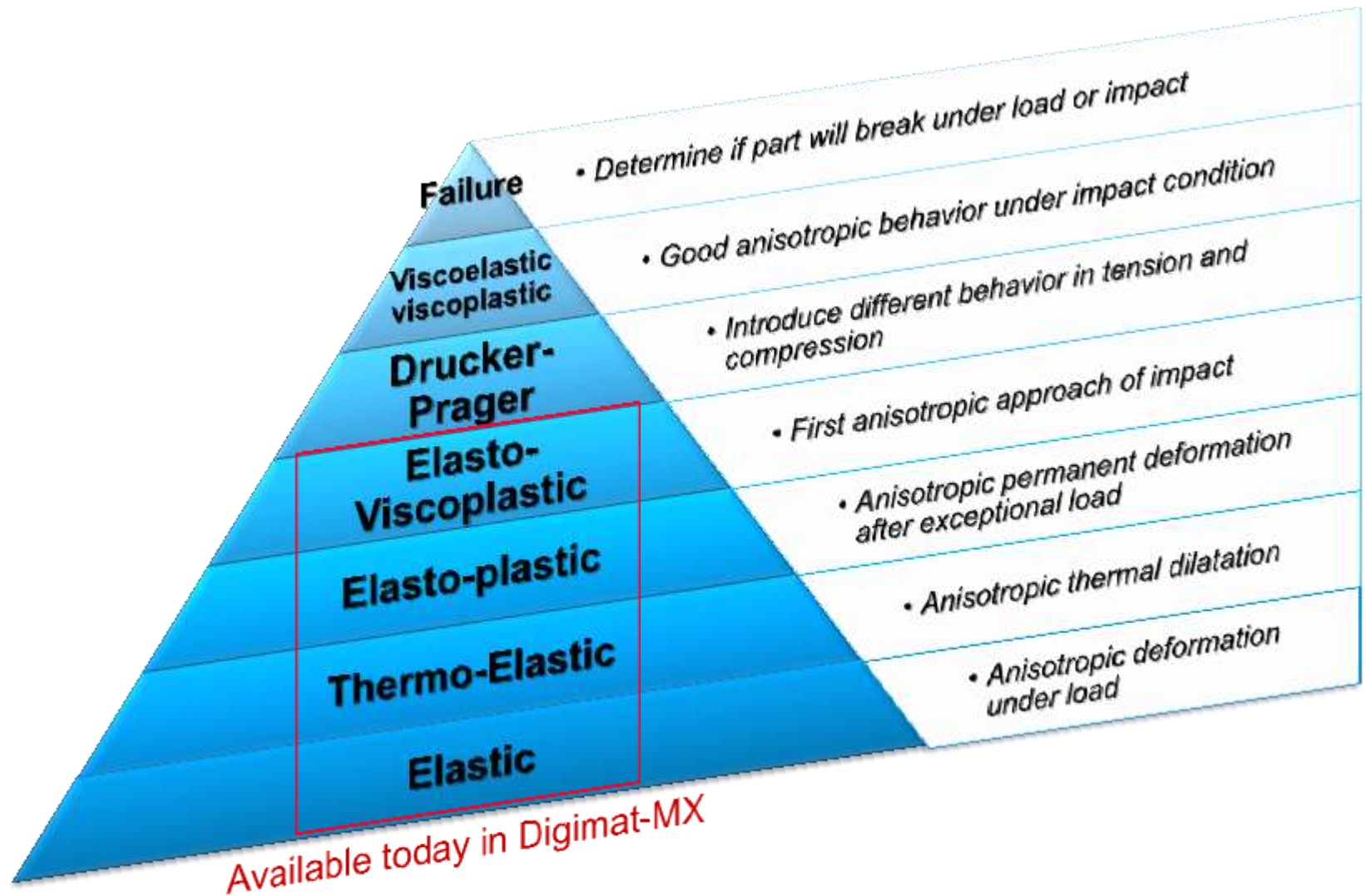
$$f_A = \frac{\epsilon_{11}^2}{X_e^2} - \frac{\epsilon_{11} \epsilon_{22}}{X_e^2} + \frac{\epsilon_{22}^2}{Y_e^2} + \frac{4\epsilon_{12}^2}{S_e^2}$$

A micro-structure dependent failure indicator !

A critical number of failed pseudo grain must be defined to activate failure.



MMI Confidential Design : Data availability



MMI ConfidentialDesign : Rhodia offer in Digimat-MX

The screenshot displays the DIGIMAT-MX software interface. The top menu bar includes File, Window, Settings, Help, and Disclaimers. Below the menu, the status bar shows 'Number of grades: 39 / 39' and 'Number of files: 78'. The main window is divided into several panes:

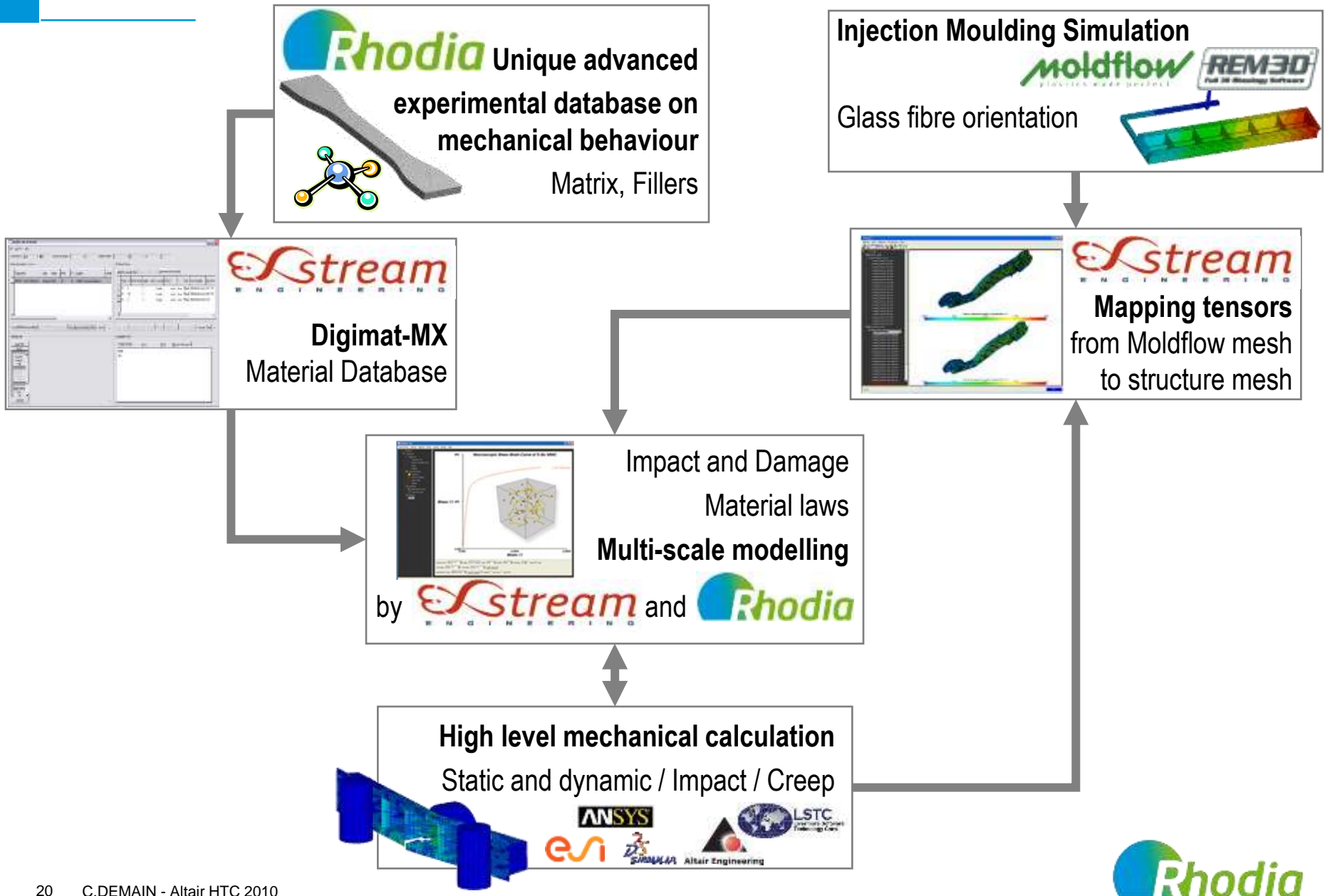
- Material Explorer:** A table listing materials with columns for Trade Name, Type, Matrix, Filler, FA, Supplier, and Comments. The first few rows are:

Trade Name	Type	Matrix	Filler	FA	Supplier	Comments
TECHNYL A 218 V35 Black 34 NG	Composite	PA66	GF	0.35	RHODIA Polyami	Polyamide 66, reinforced with 35% of glass fibre, heat st
TECHNYL A 218G2 V30 Black 34 N	Composite	PA66	GF	0.3	RHODIA Polyami	Polyamide 66, reinforced with 30% of glass fibre, heat st
TECHNYL A 218G1 V25 Black 34 N	Composite	PA66	GF	0.25	RHODIA Polyami	Polyamide 66, reinforced with 25% of glass fibre, heat st
- Data Explorer:** A table showing analysis files with columns for Matrix Model, Temp., RH, RE, Date Created, and Comments. The first few rows are:

Matrix Model	Temp.	RH	RE	Date Created	Comments
elastic	140	50	NO	2010-04-16 14:12	MMI ConfidentialDesign :
elastic	160	50	NO	2010-04-16 14:12	MMI ConfidentialDesign :
thermoelastic	20	0	NO	2010-04-16 14:12	MMI ConfidentialDesign : Thermo-Elastic matrix, for different
- DB Content Visualization:** A bar chart showing the distribution of material files across different matrix classes. The x-axis is labeled 'Matrix Class' with categories PA66 and PP. The y-axis represents the number of files, ranging from 0 to 1720. The PA66 bar is significantly higher, reaching 1638 files. The PP bar is much lower, around 40 files. A legend indicates that red bars represent DAF, blue bars represent DMF, and light blue bars represent DEF.

Rhodia offer is 1638 material files today available in DIGIMAT-MX !

M.M.I. simulation process



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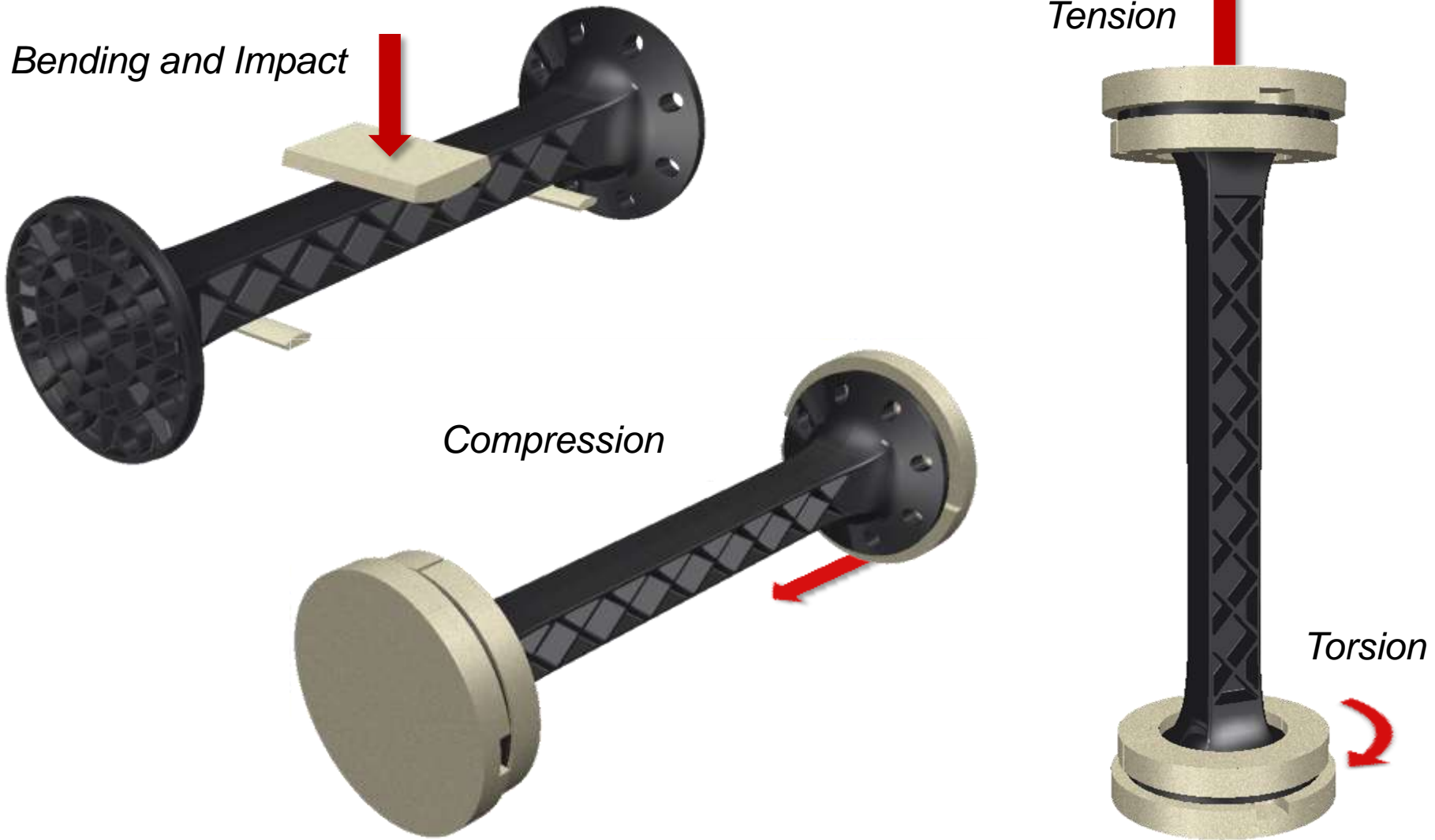
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The MMI Beam

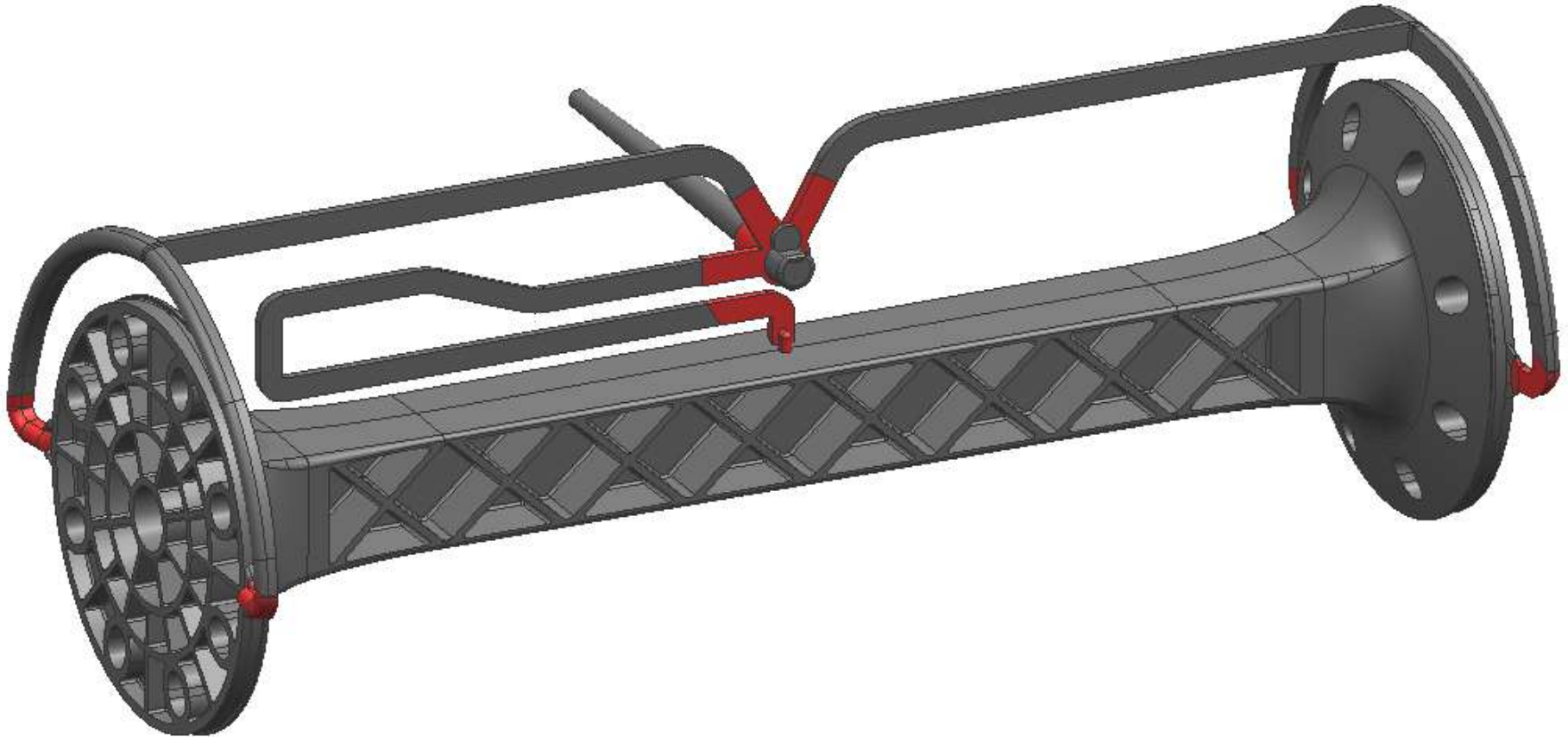
A new tool to get closer to structural parts



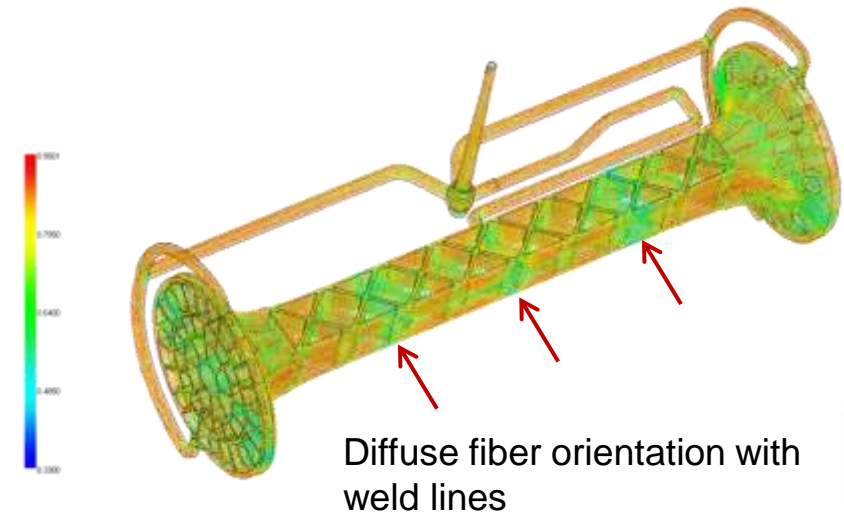
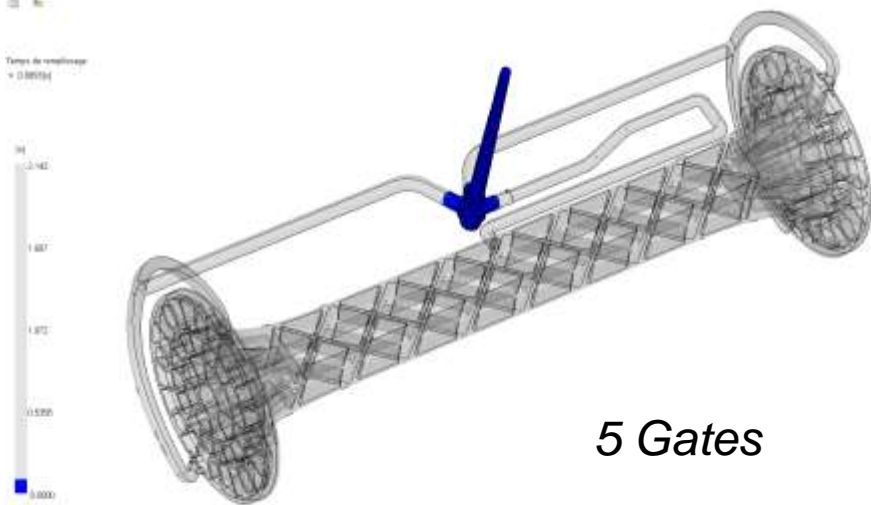
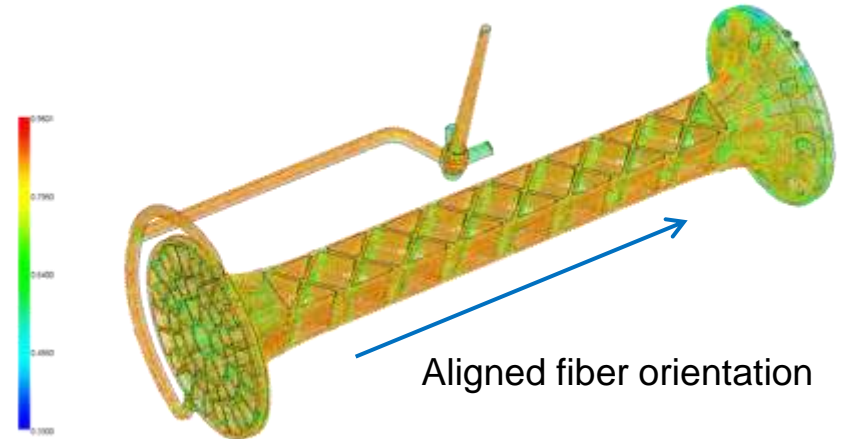
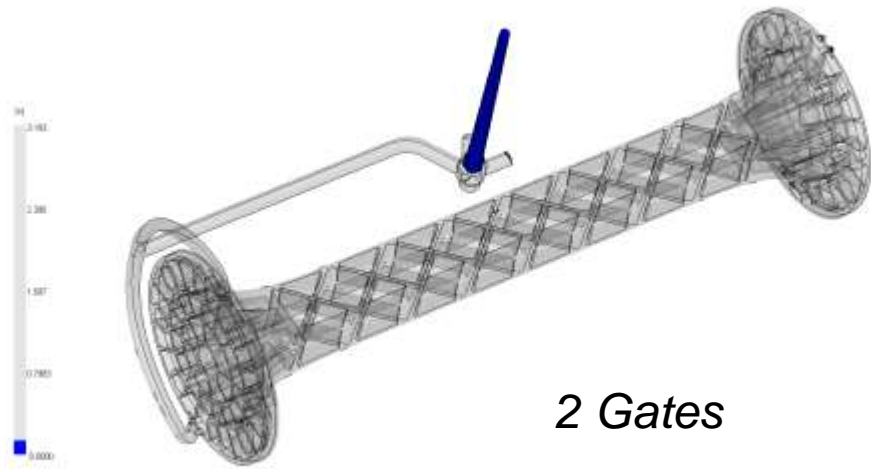
Designed for multi-testing conditions :



A multi gating design ...



... to get many different micro-structures



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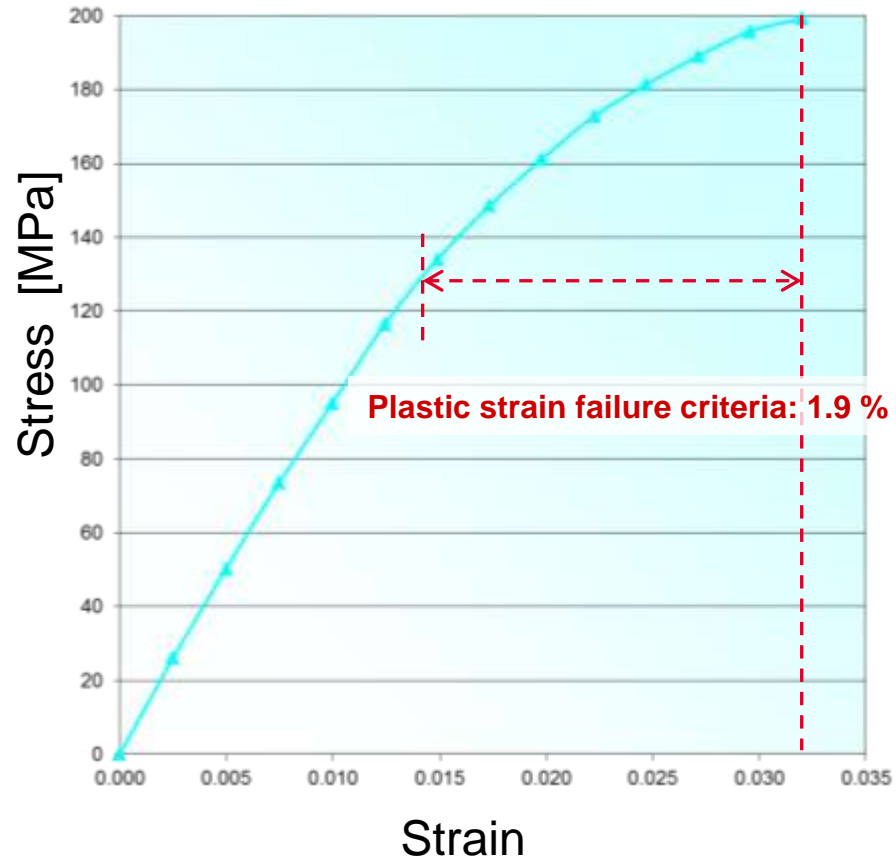
Digimat to Radioss Simulation

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Material isotropic approach

Technyl A218 V30 23°C EH0	
Density (g/cm ³)	1.37
Young modulus (MPa)	9000

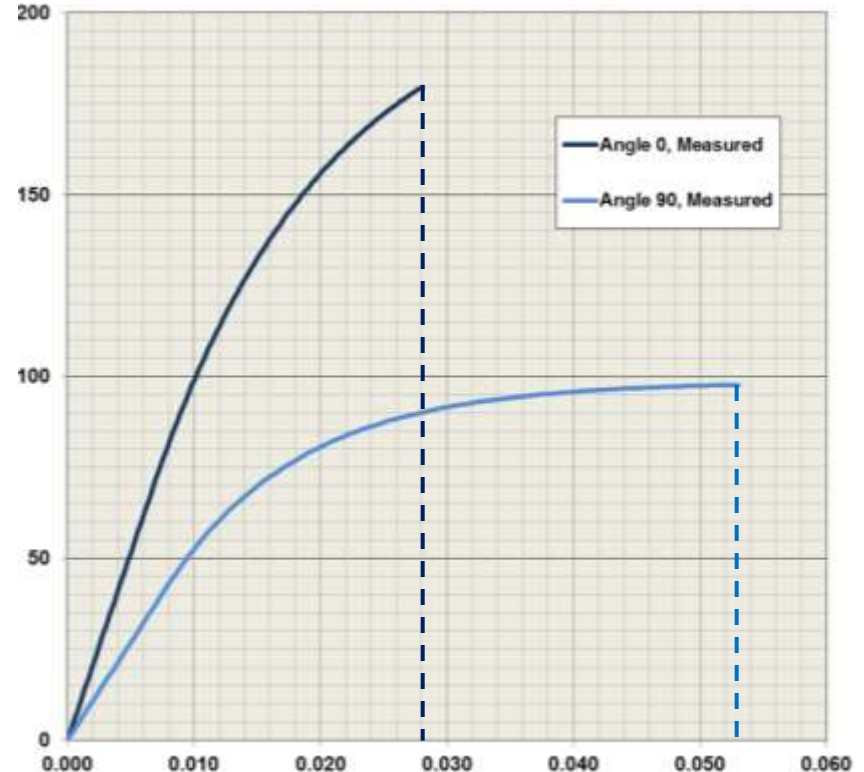


Material MMI approach

- High end use of Digimat software :
 - Glass Fiber :
 - Elastic
 - Aspect Ratio
 - Weight fraction
 - Orientation on all the part
 - PA66 Matrix :
 - Elasto-Viscoplastic
 - Fitted by M.M.I. ConfidentDesign approach
 - Failure criteria :
 - FPGF (First Pseudo-Grain Failure)
 - Fast determination of FPGF parameters

- MMI material definition fitted Elasto-viscoplastic with Basic FPGF

Max strain used as FPGF Inputs for Tsai Hill 2D strain, Critical factor 0.85, no reverse engineering



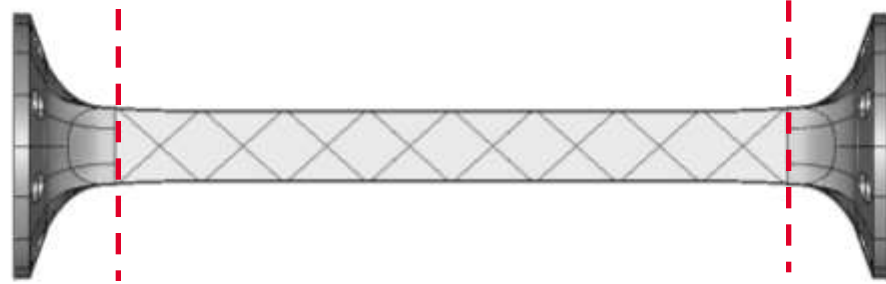
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MMI beam presentation of impact model

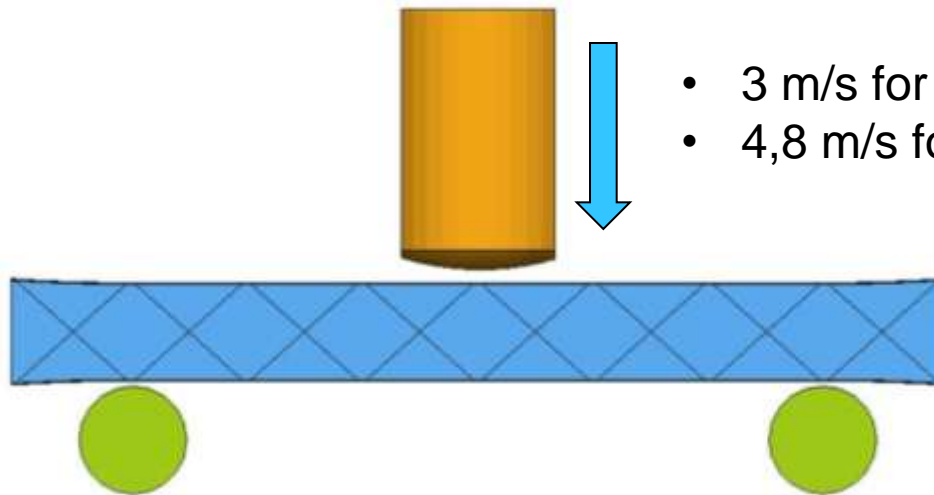
- Beam

The sides were cut off



- Dynamic flexion test

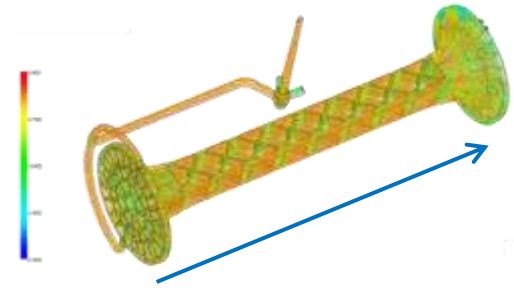
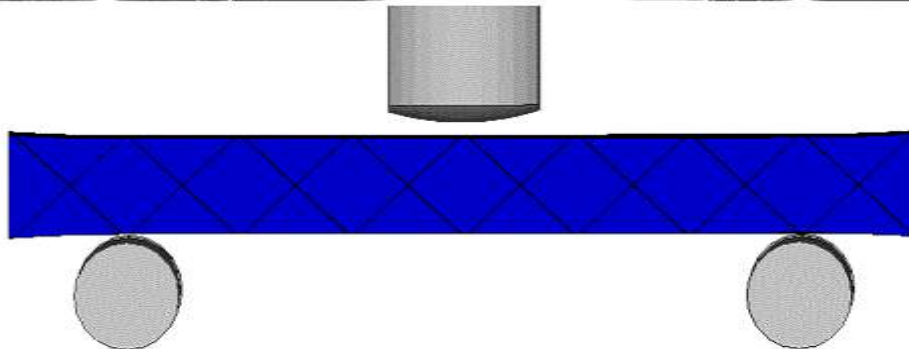
Mass of 18 kg



- 3 m/s for 5 gates
- 4,8 m/s for 2 gates

MMI beam – 2 gates

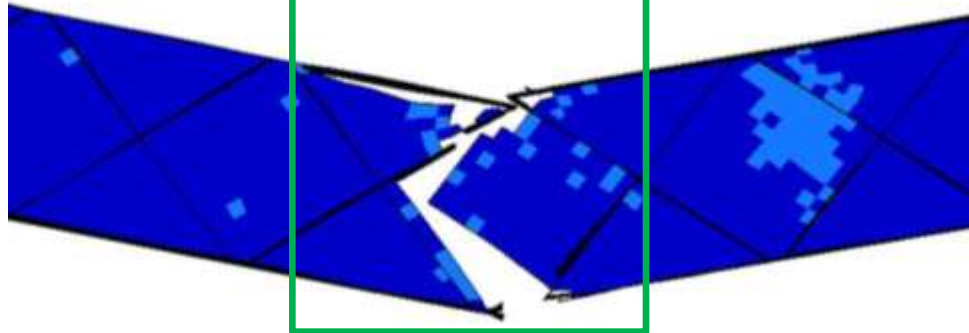
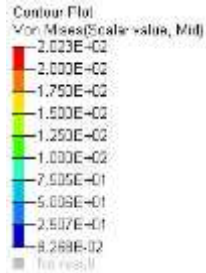
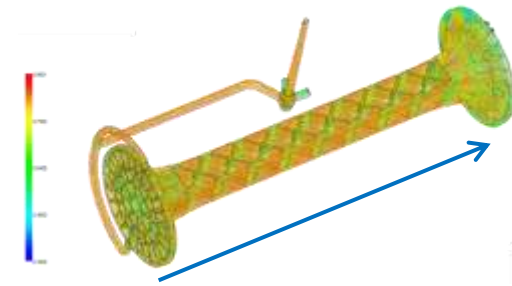
correlation experiment / MMI



MMI beam – 2 gates correlation experiment / MMI



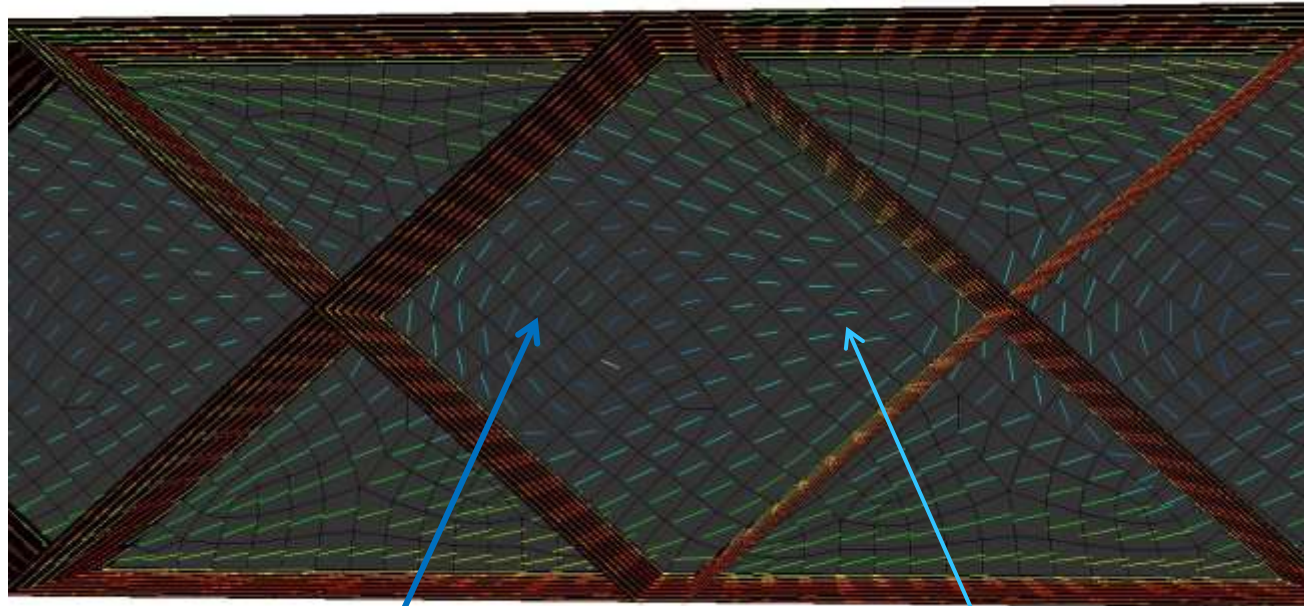
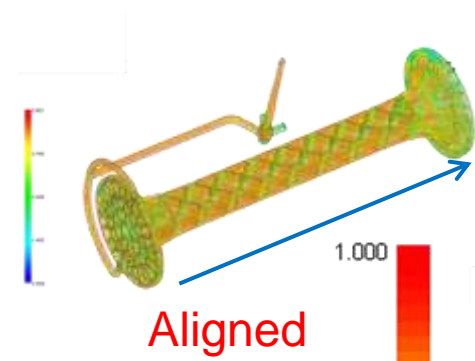
Failure at the same
time



MMI beam – 2 gates

Failure prediction

The failure area could be explained by the fiber orientation



Transverse on stress

Aligned on stress

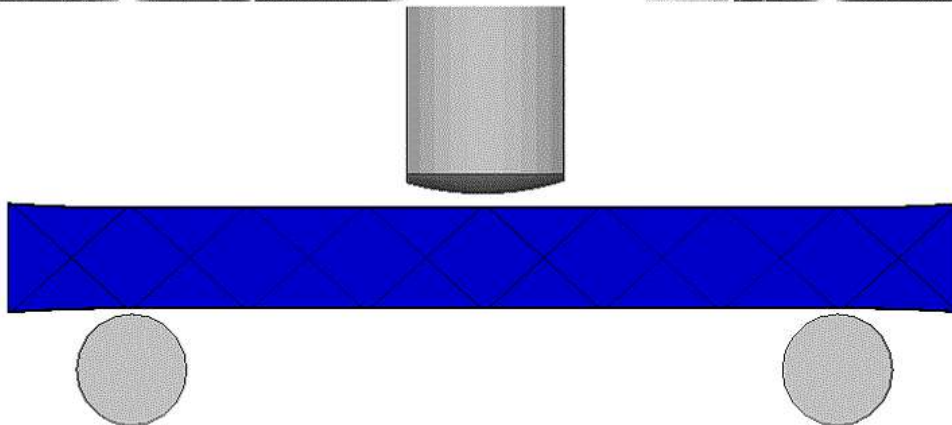
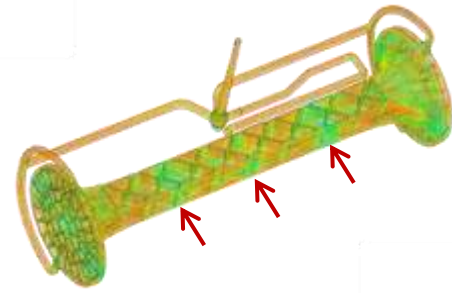
Weak zone

Diffuse



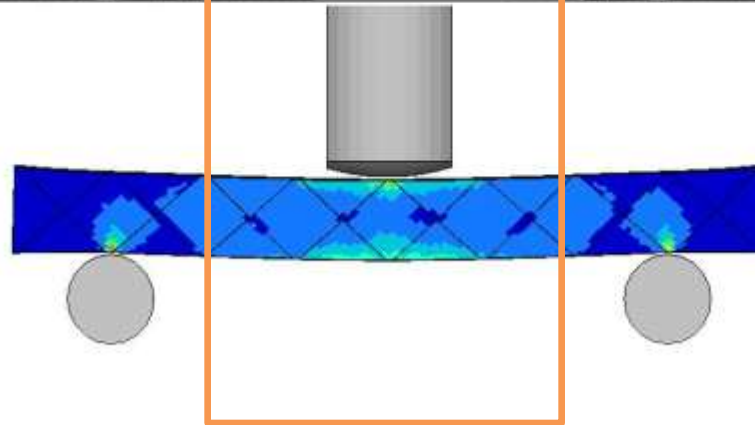
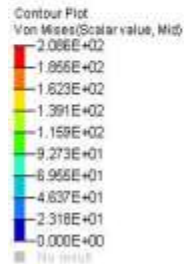
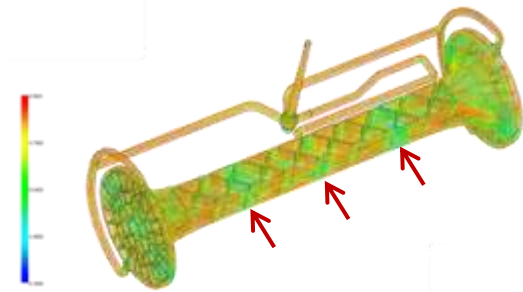
MMI beam – 5 gates

Failure prediction



MMI beam – 5 gates

Failure prediction

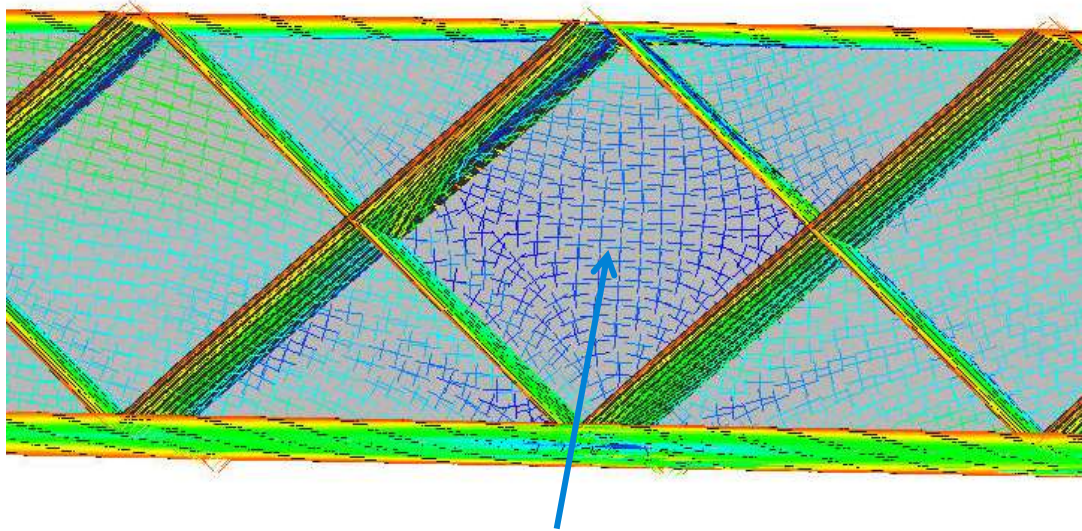


Failure occurs too late

MMI beam – 5 gates

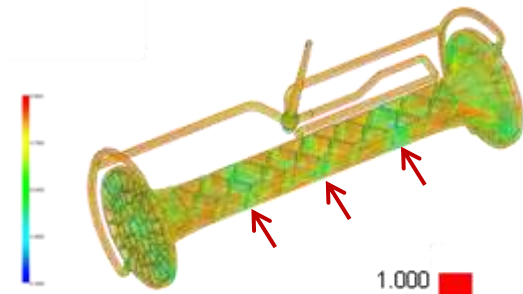
Failure prediction

The failure area could be explained by the fiber orientation



diffuse

Weak zone



Aligned

1.000

0.8750

0.7500

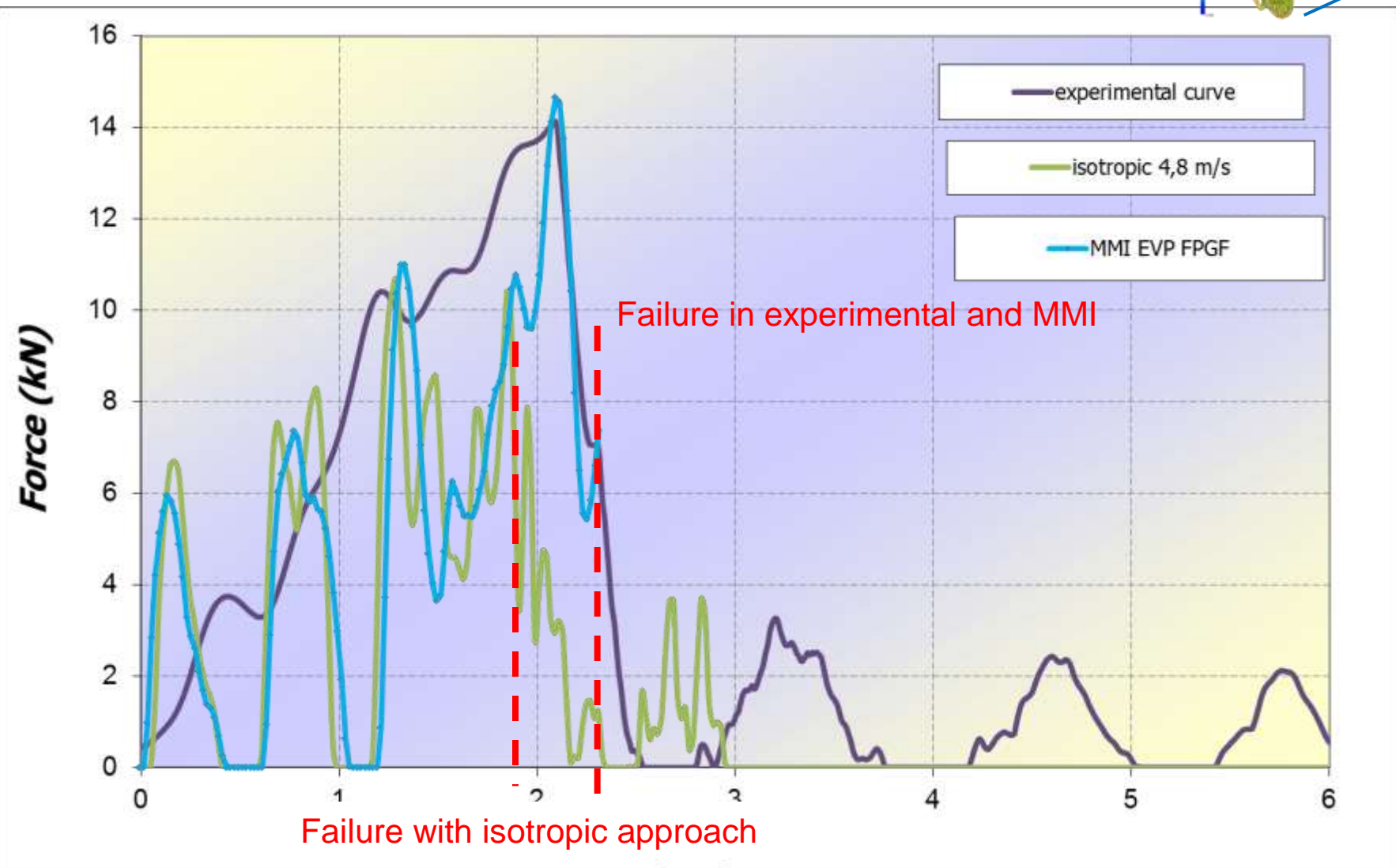
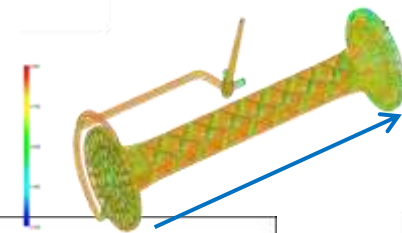
0.6250

0.5000

Diffuse

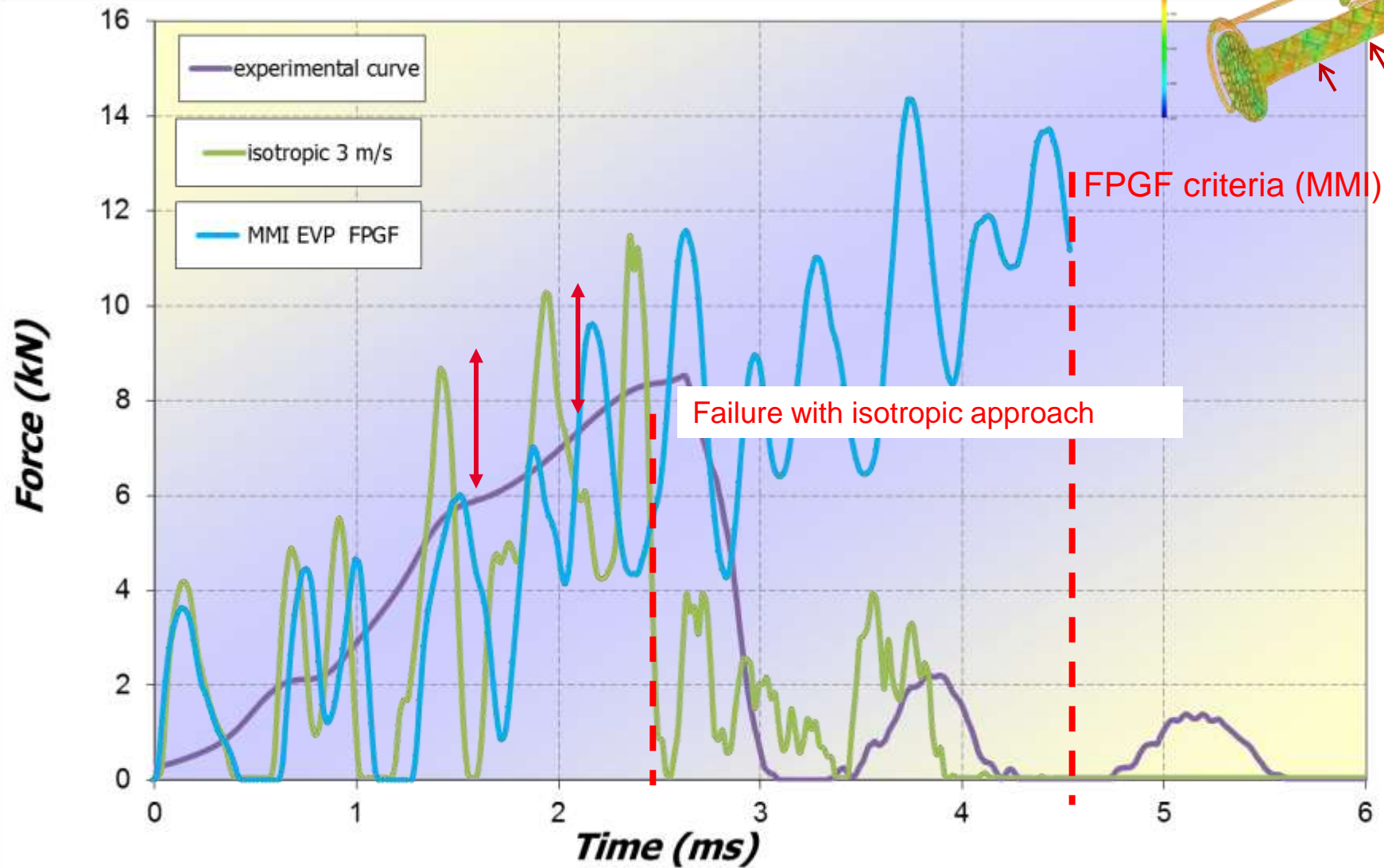
MMI beam – 2 gates

Force correlation



➔ Good correlation in force and failure

MMI beam – 5 gates force correlation



No correlation in failure with FPGF criteria,
MMI approach is closer to test in stiffness

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Conclusion

Conclusions

- With a fast determination of FPGF parameters :
 - We obtain some interesting results in 2 gates case :
 - Correlation in term of failure and force
 - Failure related to microstructure
 - The failure model is very promising
- To be improved :
 - FPGF parameter
 - Run MMI fitting process on FPGF parameters to get better value on transverse and shear !
 - Material behavior
 - Add hydrostatic pressure dependency (tension/compression behavior)
 - Altair Hyperview
 - Add the possibility to compute specific outputs of Digimat vs times (for example to calculate Von Mises stress) and animate

