



HOW DOMO BRINGS ITS SIMULATION MATERIAL DATABASE TO THE NEXT LEVEL

Elodie Seignobos, Alexandre Chatelain, Gilles Robert, Barbara Autuori, Frederic Brun

DOMO CHEMICALS

AT A GLANCE



2,150



€1.5 Bill.



10 OPERATION sites



6 INNOVATION & TECHNICAL centres

BUSINESS areas

- Polymers & Intermediates
- Engineered Materials
- Nylon Film Solutions
- Performance Fibers
- Trading & Distribution

MARKETS



AUTOMOTIVE



INDUSTRIAL & CONSUMER GOODS

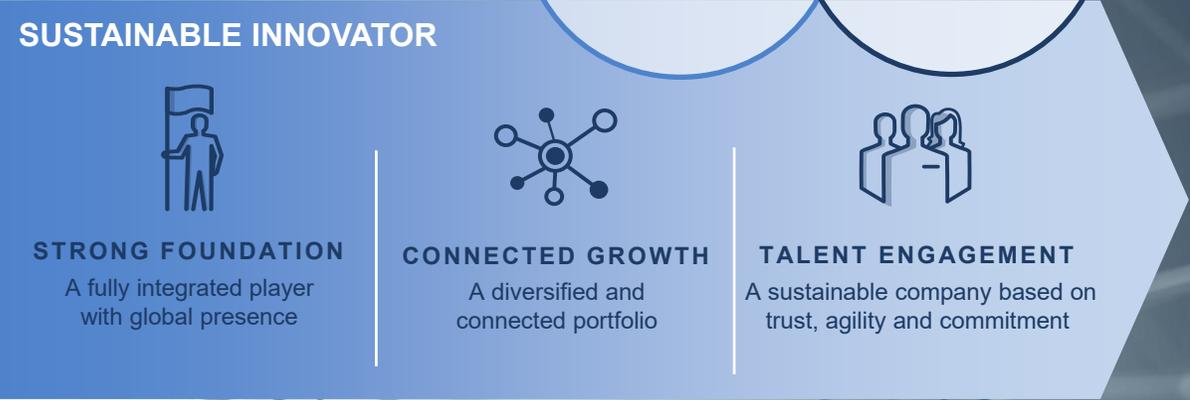


ELECTRIC & ELECTRONIC



OUR STRATEGIC VISION

DOMO CHEMICALS' STORY OF ACCELERATION



MATERIAL ENGINEERING

NYLON SPECIALIST



1994

Caprolactam, Leuna

2004

Engineering Plastics, PA 2000 – Premnitz

2013

Engineering Plastics, Aquafil – Italy/US/China

2015

Flexible Packaging, Cfp – Italy
Engineering Plastics, Technical Polymers – US

2018

Michiels Advanced Materials (M.A.M) participation – Belgium

2019

Solvay Performance Polyamides Europe

2028

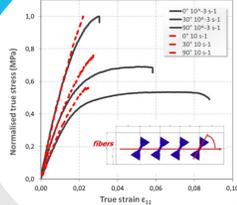
A UNIQUE SERVICE OFFER

SUPPORTING FAST CHANGING MARKET NEEDS



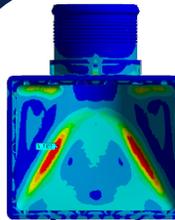
MATERIAL DATABASE & SCIENCE

Advanced mechanical characterization to offer exhaustive and highly predictive material database



SIMULATION

Advanced predictive simulation to get numerical validation of a new design



APPLICATION VALIDATION

Fast and flexible part testing capabilities to homologate designs for a variety of applications



DESIGN OPTIMIZATION

Function integration, topological optimization, mold design support



PROTOTYPING



Additive manufacturing of functional prototypes ready to be tested

UNMET NEEDS ADDRESSED BY SIMULATION



CUSTOMERS NEEDS

- Avoid trial and error costs in development phases**
- Reduce material costs**
- Increase confidence in new design developments**
- Optimize production costs**



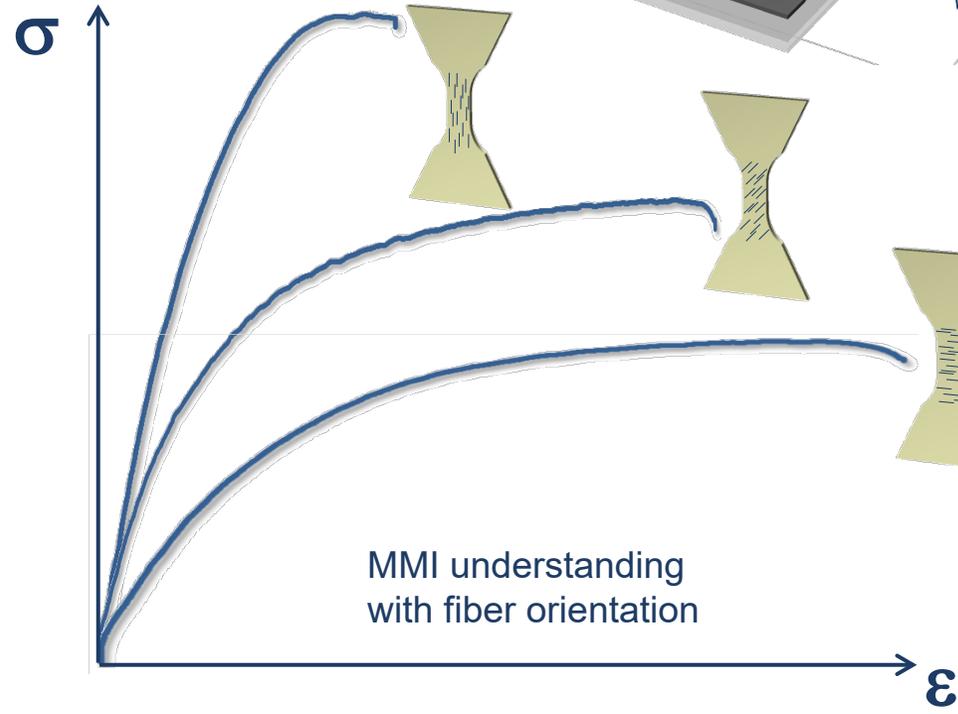
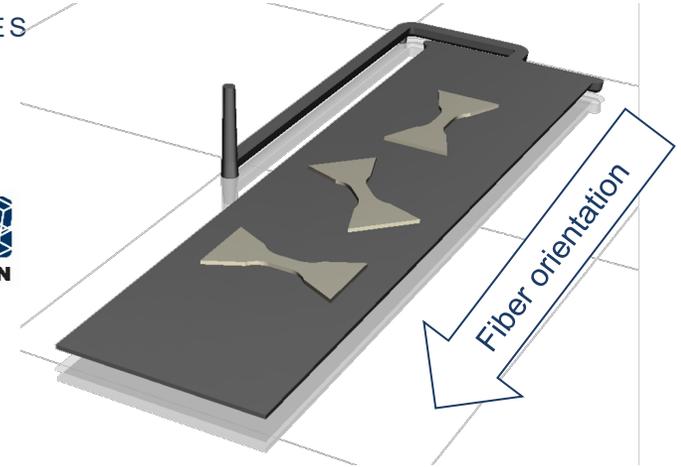
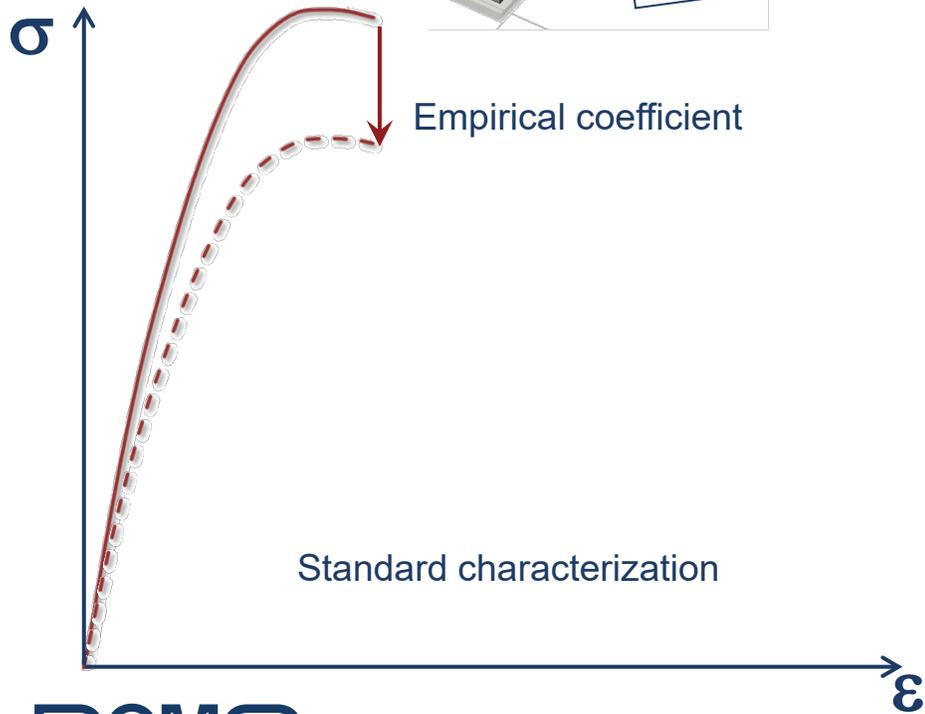
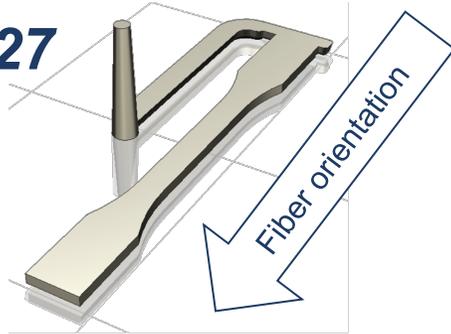
DOMO Simulation services offer

- Virtual prototyping**
predictive simulation based on local GF orientation and polymer behavior
- Design optimization**
Evaluate and maximize Technyl performance vs metal or other polymers
- Part performance prediction**
Numerical validation of part performance
- Processing expertise**
Avoid processing problems and recommend best production parameters

ADVANCED MATERIAL CHARACTERIZATION

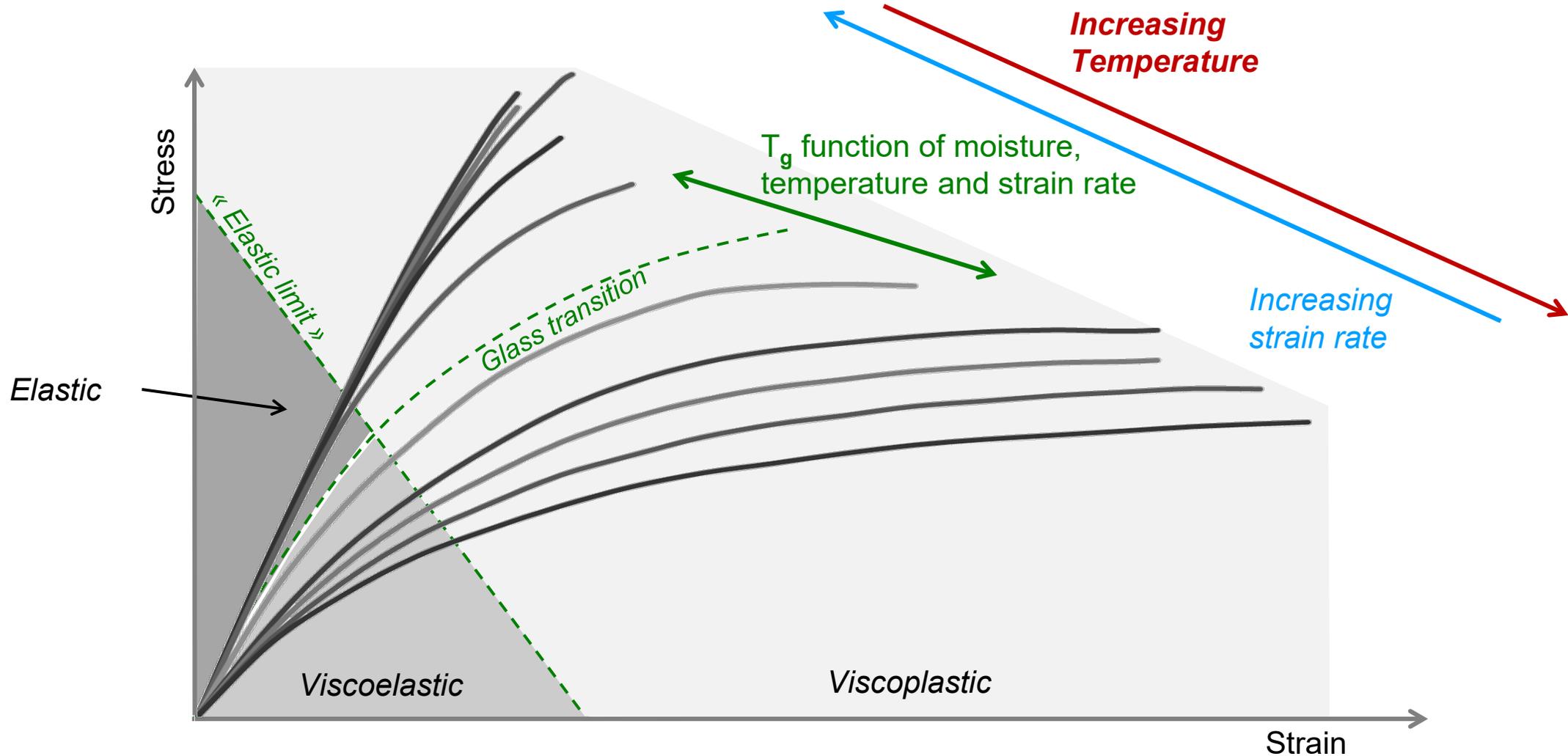
TO USE THE FULL POTENTIAL OF TECHNOL COMPOUNDS FOR GLASS FIBER FILLED GRADES

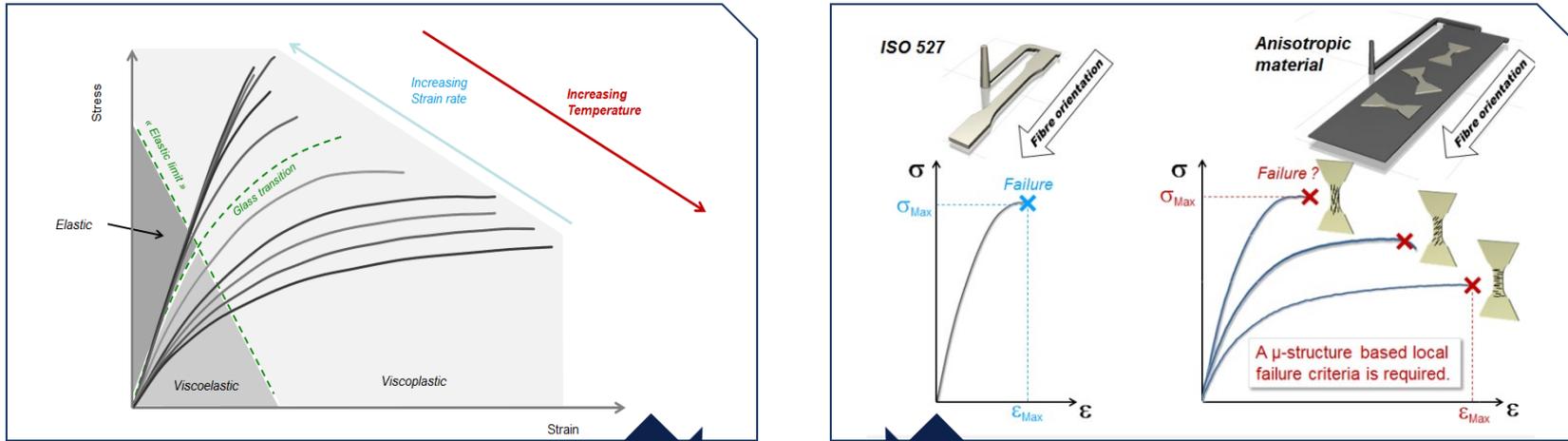
ISO 527



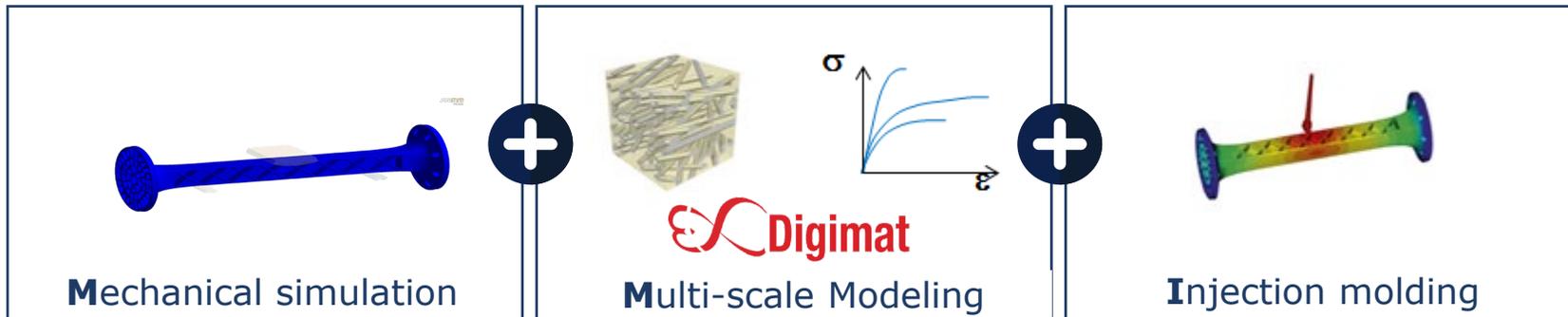
ADVANCED MATERIAL CHARACTERIZATION

POLYAMIDES SHOW A COMPLEX MECHANICAL BEHAVIOR



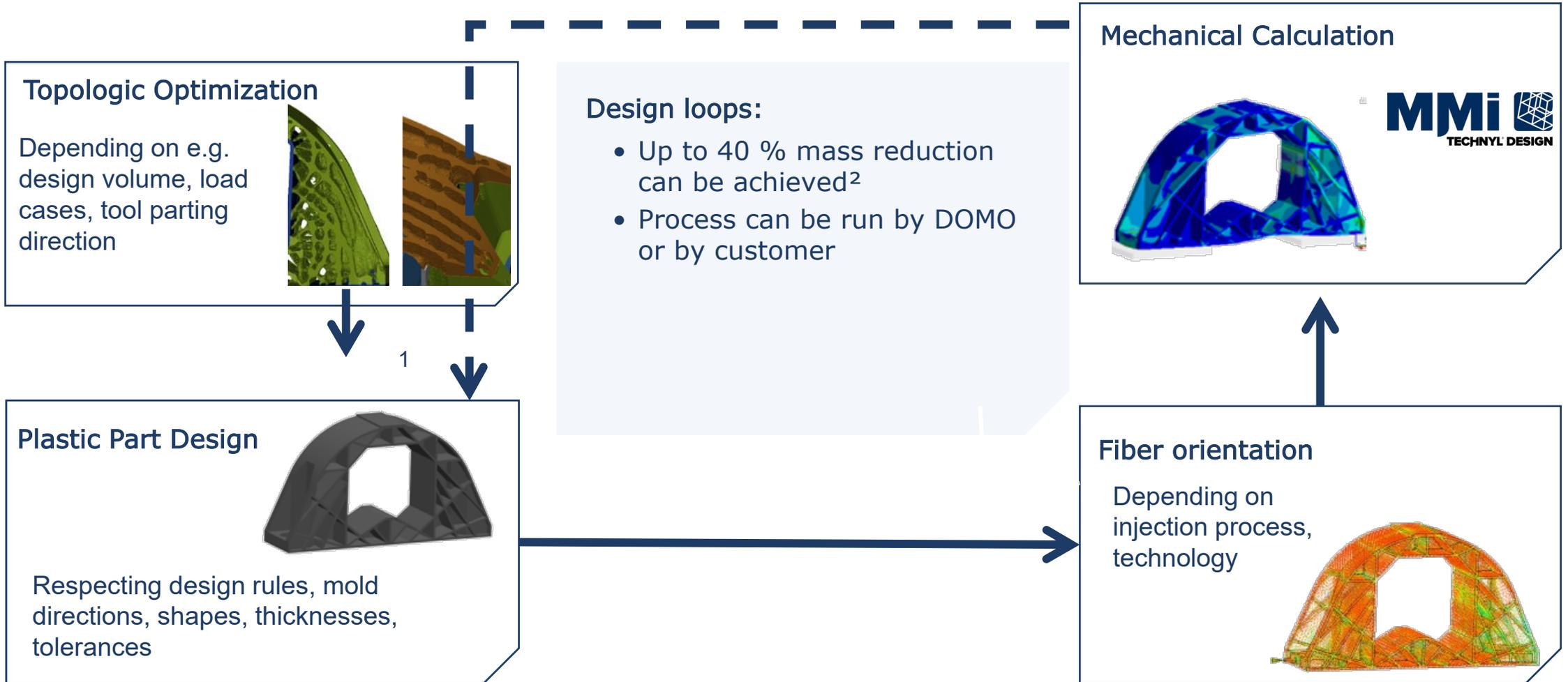


MMi TECHNICAL DESIGN



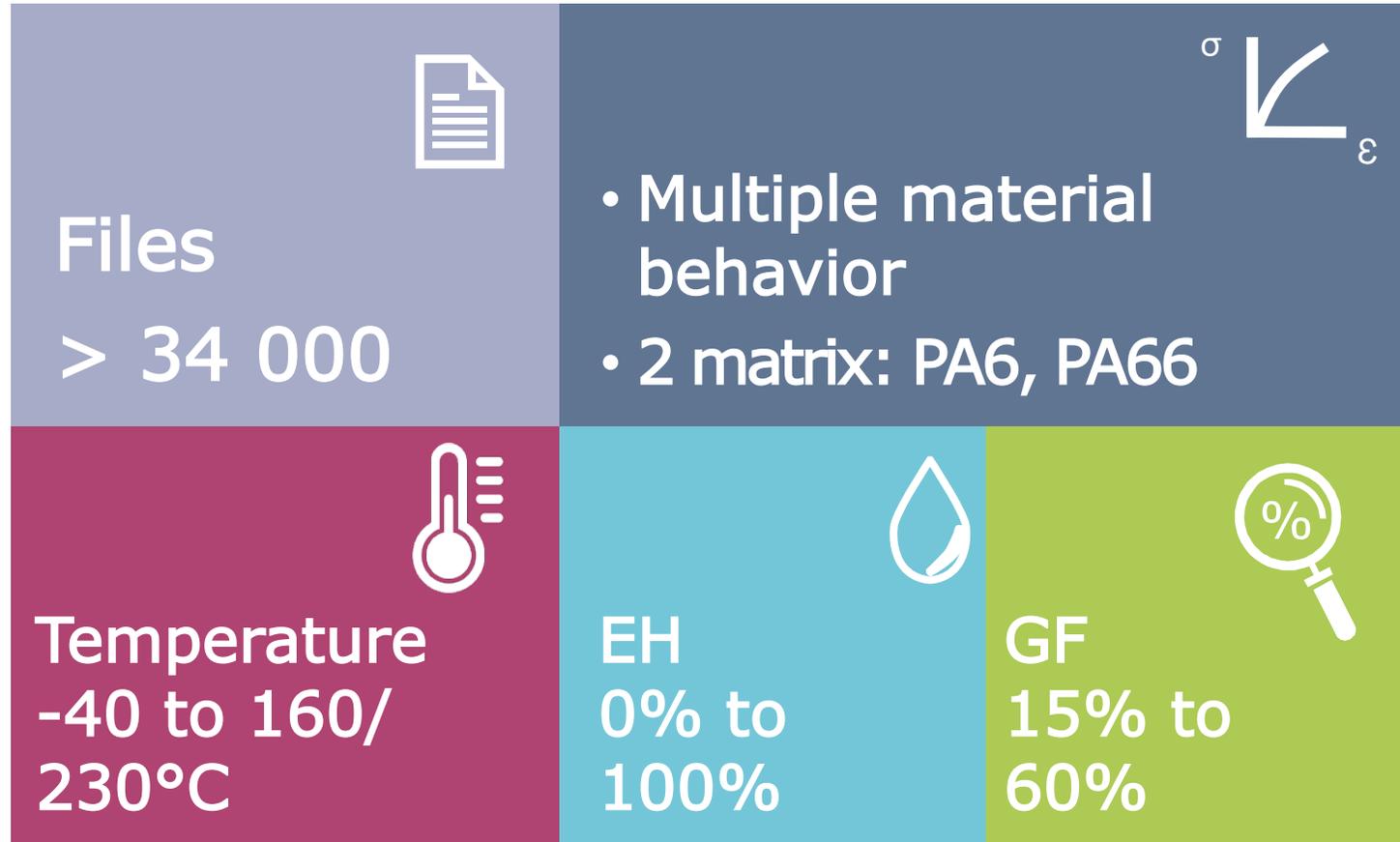
FROM THE IDEA TO A DIGITALLY VALIDATED DESIGN

METAL REPLACEMENT PROCESS WITH **MMi**



MMI[®] DATABASE

THE MOST EXHAUSTIVE AND RELIABLE DATABASE OF DIGIMAT MATERIAL CARDS

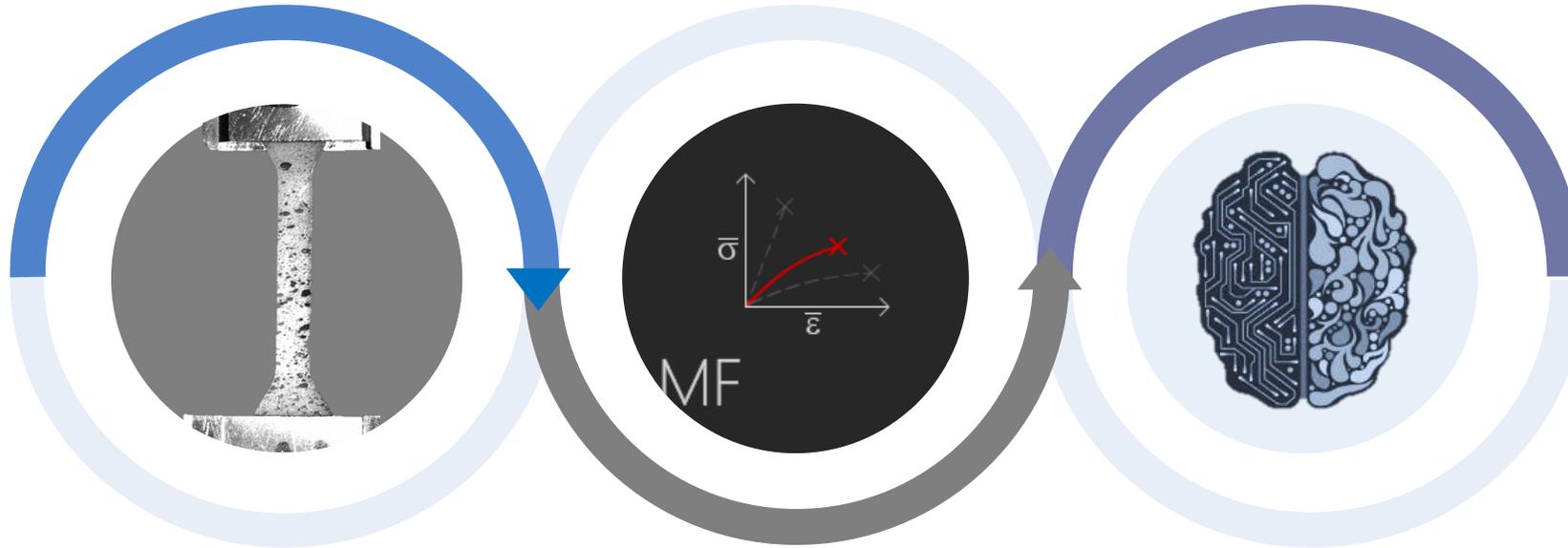


- **Static load and failure**
Deformation under load for elastic and elasto-plastic behaviors, permanent deformation, prediction of failure
- **Impact, Crash**
Strain-Rate dependent elasto-plasticity (short-term)
- **Modal, NVH, Damping**
Visco-elastic behavior (short-term)
- **Fatigue**
Consider effect of alternate loading, with frequency and load ratio, for elastic and visco-elastic behavior
- **Thermal dilatation and warpage**
Thermo-elastic and thermo-elasto-plastic behavior
- **Effect of moisture and glycol**
Elastic and elasto-plastic behavior at various humidity rates and glycol content to take into account the plasticization phenomena

HOW DO WE CREATE THESE FILES?

Material properties are carefully measured under large amount of conditions:

- Strain Rate
- Temperature, Humidity
- True stress, true strain



Reverse Engineering

Machine Learning

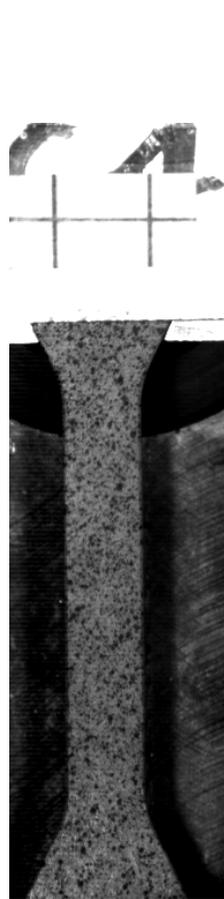
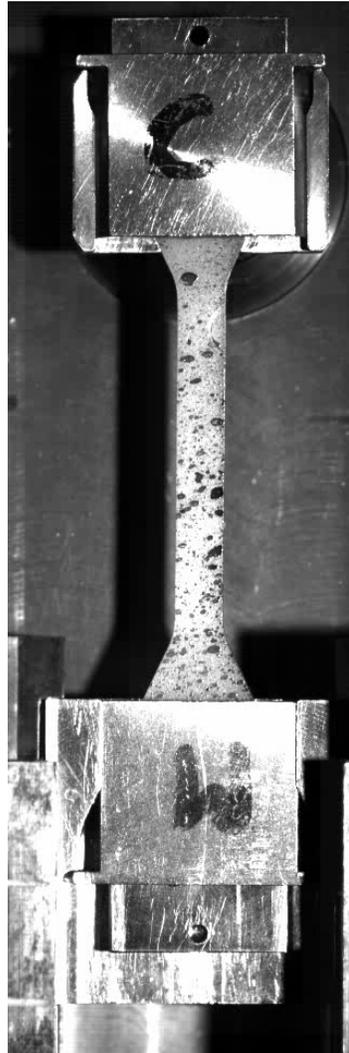
x10+ reverse engineering efficiency
+15% accuracy vs classical approach

In-house developed method for matrix parameters identification based on Glass fibers measurements:

- Orientation tensor
- Fiber length distribution

HIGH SPEED MATERIAL CHARACTERIZATION

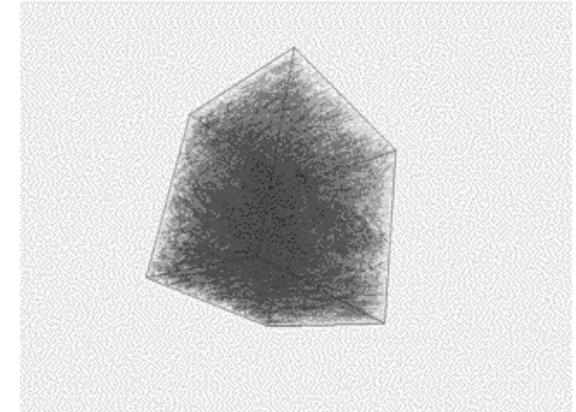
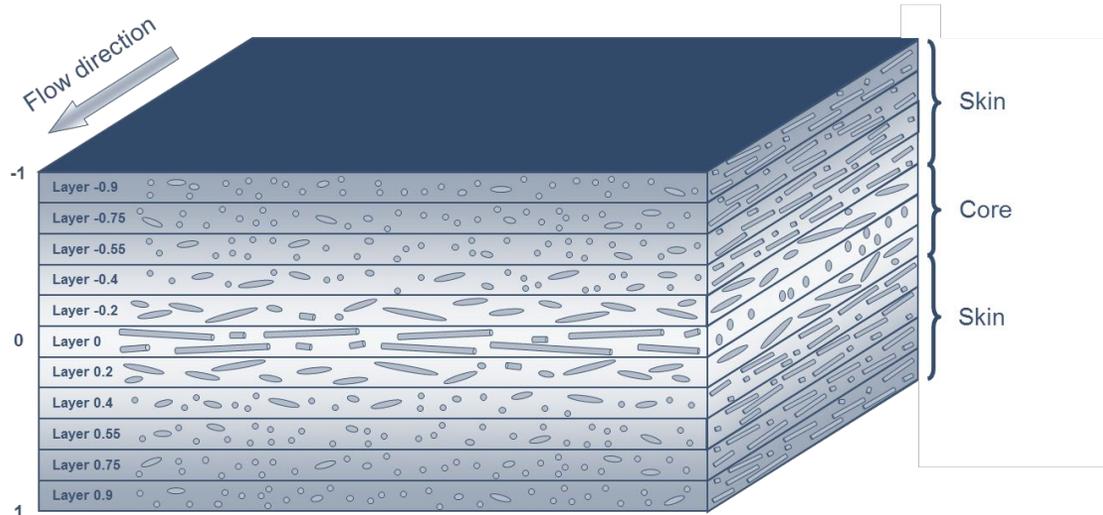
HIGH SPEED CAMERA AND POST PROCESSING ($\dot{\epsilon} > 1S^{-1}$), ADIABATIC



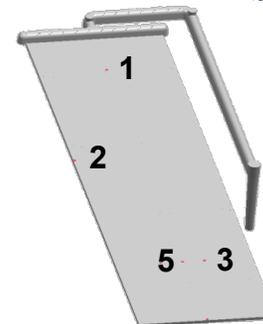
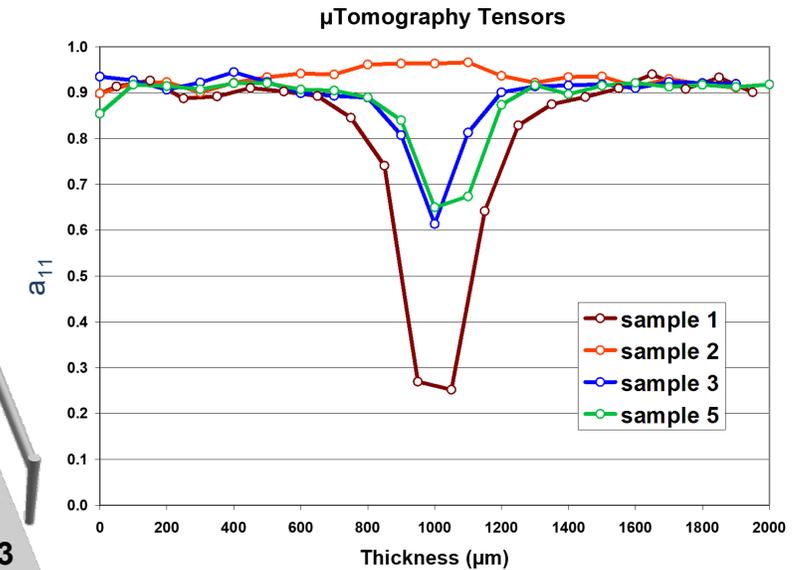
Use of high speed camera and digital image correlation to post process true strain rate

MICROSTRUCTURE CHARACTERIZATION

OF FIBER REINFORCED POLYMERS



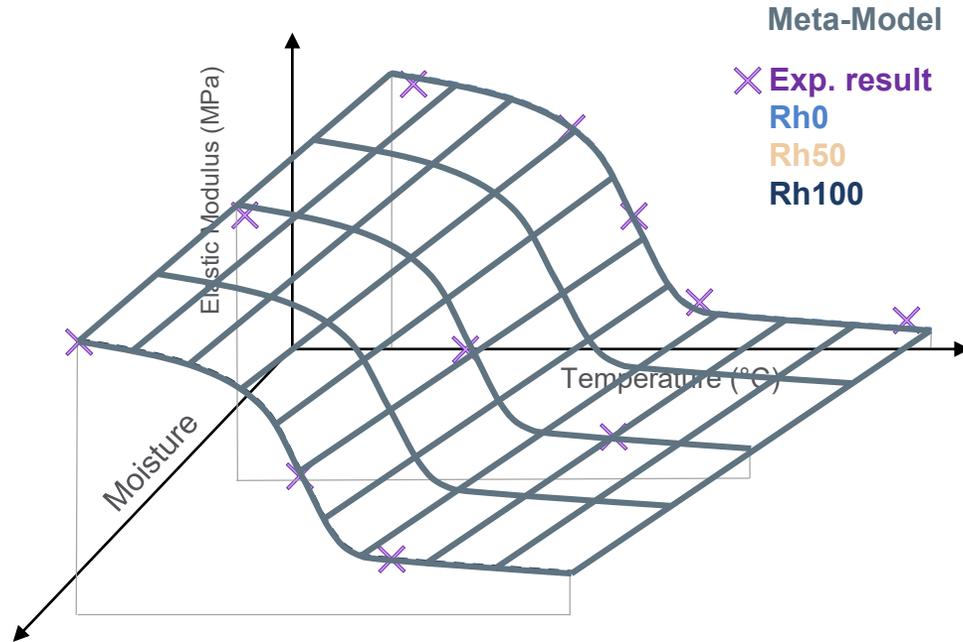
$$\begin{pmatrix} a_{11} & a_{12} & a_{13} \\ & a_{22} & a_{23} \\ & & a_{33} \end{pmatrix}$$



- Core may vary from 0% to 90% of the thickness
- Core fibers can be aligned in flow or in transverse direction
- High power X-Ray used to scan a sample
- High resolution experimental tensors are used as microstructure input for Digimat material model calibration.

PRODUCE MORE DATA WITH SAME RESOURCES

USE OF META MODELS



Exhaustive testing would represent **Dozens of years** of testing.

We prefer to keep the **high level of measurement accuracy** and use metamodels to reduce the number of tests

The methodology of fitting enables a high reliability since it is **based on polymer physics**.

This **metamodel methodology** enables to take into account the effects of temperature, humidity and strain rate.

→ Specific management of the Material Database is required, since we want to keep a high level of quality check and regular database update

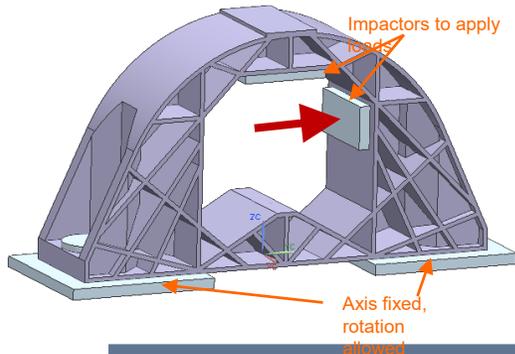
WITH MMI™ TECHNICAL DESIGN

PART BEHAVIOUR PREDICTION

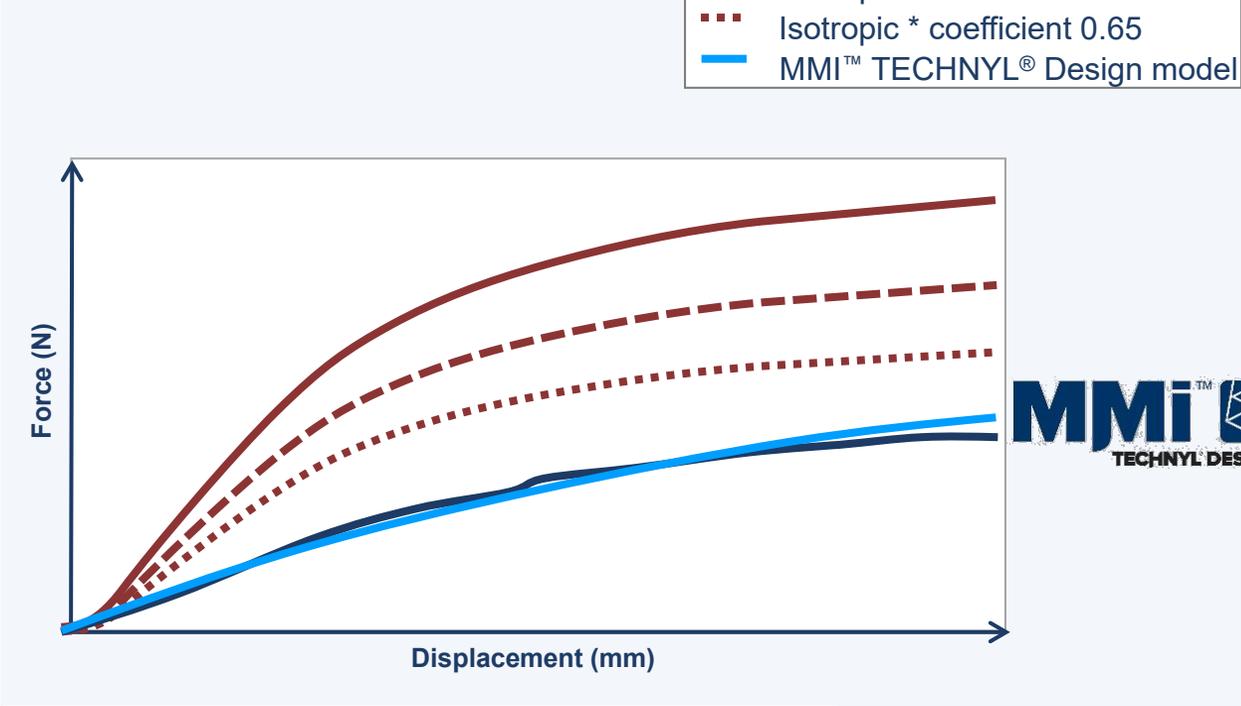
ENGINE MOUNT PART TEST:

Test conditions

Water content: RH50
 Temperature: 80°C
 Testing velocity: 10 mm/min
 Force in Y-direction



With empirical coefficient:
 Not predictive
 Not at specification
 Need of additional prototype
 High cost



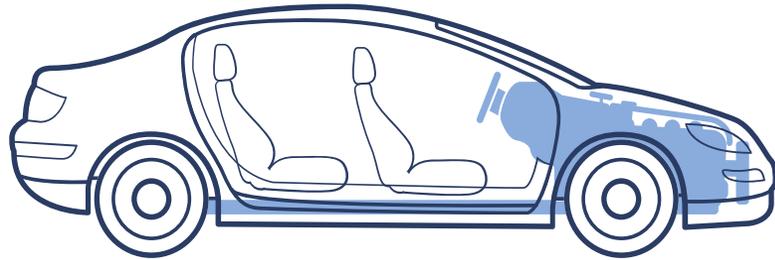
With MMI™ TECHNICAL DESIGN:
 Predictive
 At specification
 Good at first time
 Right cost

- Measurement
- Isotropic (ISO527)
- - - Isotropic * coefficient 0.8
- ... Isotropic * coefficient 0.65
- MMI™ TECHNICAL DESIGN model



ALREADY ON THE STREETS

THANKS TO MMI™ TECHNYL® DESIGN



UNDER THE HOOD



Weight: - 40%



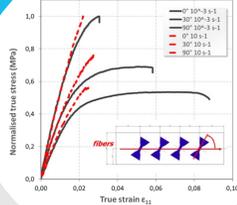


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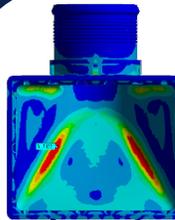
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UNMET NEEDS ADDRESSED BY PART TESTING



CUSTOMERS NEEDS

- Increase testing capacities**
- Validate new applications**
- Choose the right material**
- Reduce developments costs**

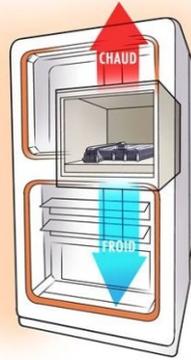


DOMO Part Testing offer

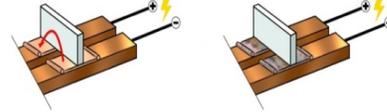
- Access to wide range of tests**
Providing various test benches, including long term ageing (glycol, air, oil)
- Development of new equipments**
for specific needs, ability to ensure none standard testing according to customer wishes
- Material benchmark**
Ensure testing with different materials, choice the best balance technical / economical
- Inhouse certified testing**
IATF 16949 and GM 3155 certified laboratory

A WIDE RANGE OF PERFORMANCE TESTING CAPABILITIES

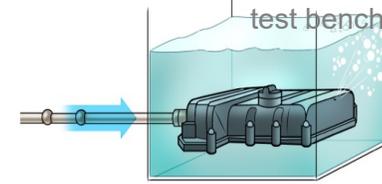
Thermal chambers
(including 1 thermal shock and 1 climatic chamber)



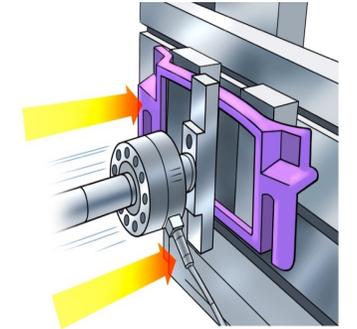
Corrosion test bench
according to IEC 60426



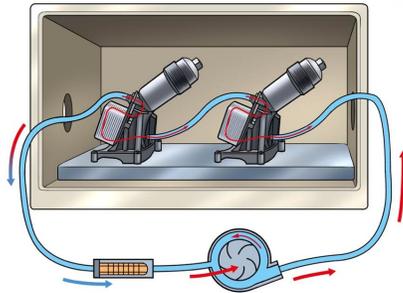
Leakage
measurement
test bench



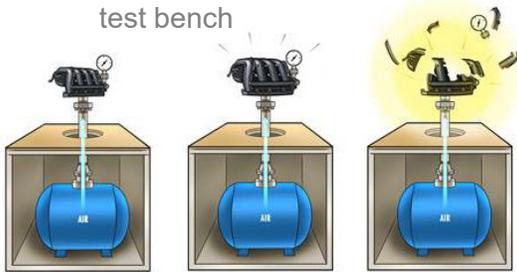
Hydraulic test bench
for structural application



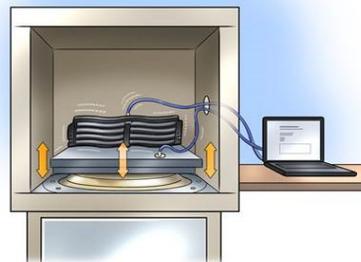
Coolant circulation
test benches



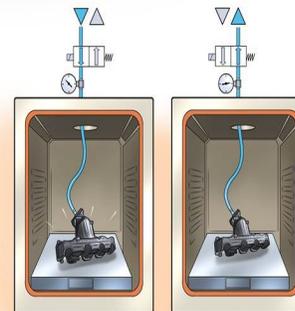
Burst pressure
test bench



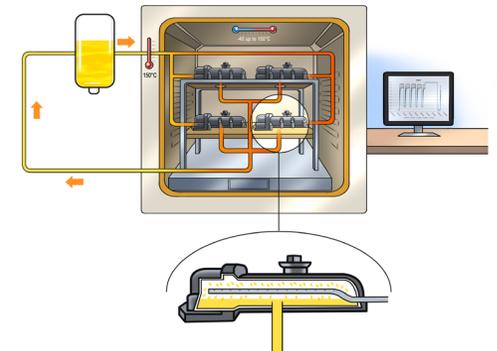
Electro dynamic shaker
(20-2000Hz, 17000N)



Air pulsation
test benches
(one with hot air)



Oil circulation test bench
Certified by GM for GM3155 validation



MMi OUR JOURNEY

TECHNYL DESIGN

DAMOFIP

The first trial for static behaviors

DAMAge Of Fiber reinforced Plastics

Partners : TECHNICAL, e-Xstream, Cemef and UCL

Deliverables in 2010 :

- Static and crash simulation
- MMI™ TECHNICAL® Design material database

1

DURAFIP

The collaborative program to predict durability

DURability of Fiber reinforced Plastics

Partners : PSA, Sogefi Filter division, Toyota, e-Xstream, TrelleborgVibracoustic, TECHNICAL and academics

Deliverables in 2016 :

- Fatigue simulation
- Material database
- Validation on industrial cases

2

THERMOFIP

The ongoing development on thermal and fluid aging

THERMAL behavior Of Fiber reinforced Plastics

Partners: CEMEF, ADI, AROBAS, ENSAM, RENAULT, e-Xstream, LMGC, NOVITOM, PROMOLD, SOGEFI, TOYOTA

Deliverables in 2022 :

Prediction of material behavior when submitted to thermal, hydro and glycol aging

3

CONCLUSION

GOOD PARTNERSHIP DEDICATED TO CUSTOMER NEEDS

Technyl® validation cases
to offer our customers
a good quality level
of our materials files

Tailor-made offer
Simulation performed by DOMO or
MMI® Technyl® Datacards
Shared with  users



Collaboration with customers
and academics to generate
new material behavior laws

New materials
are continuously added
in the database

**THANK
YOU**



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MMI DESIGN

GET IN CONTACT WITH
US FOR ANY ADDITIONAL
INFORMATION

Q&A