MMI
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FROM MATERIAL SUPPLIER TO INNOVATION PARTNER

JOINING TECHNOLOGY AT ITS BEST:

MMI STRUCTURAL SIMULATION AND VALIDATION OF VIBRATION WELDED POLYAMIDE PARTS

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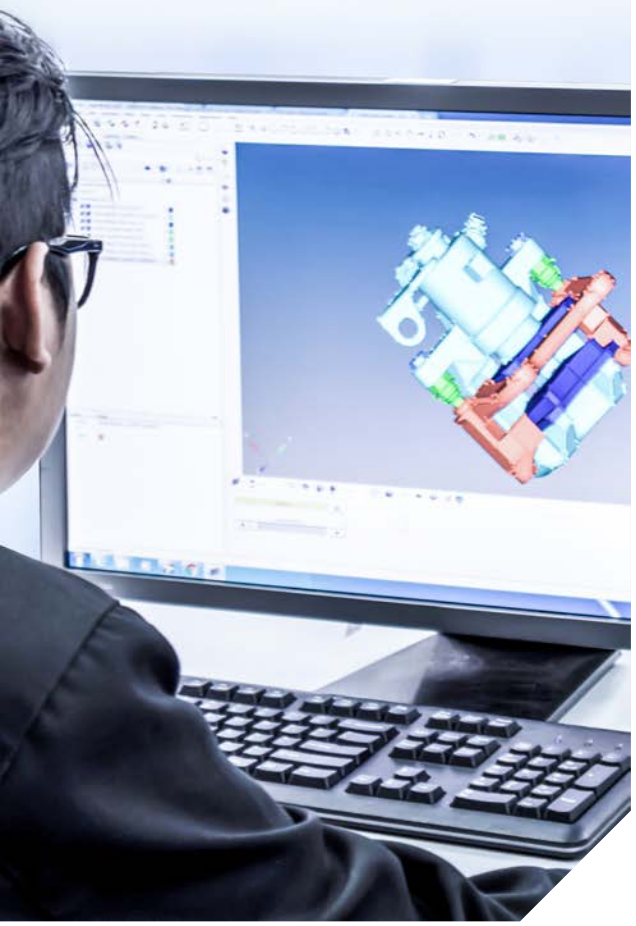


AGENDA

DOMO Chemicals

- Our company – our presence – our ambitions
- Polyamides – The right choice for demanding applications
- Our way of bringing additional value for our customers

MMI structural simulation and validation of vibration welded polyamide parts

- Demonstrating material and part performance
- The welding demonstrator and its capabilities
- Integrated structural MMI simulation of welded parts
- Correlation of simulation and testing

Conclusions

- Key insights

Q&A session

DOMO ENGINEERED MATERIALS

THE HOME OF ENGINEERED POLYAMIDE EXCELLENCE

STRONG INTEGRATED POSITION

… uniquely integrated and connected businesses, from benzene to engineering plastics compounds

SUSTAINABLE INNOVATION

… Proven industrial technology & innovation expertise to better serve our customers, sustainability-driven, customer-centered innovation

Committed to the future of polyamide

PERFORMANCE BRANDS

…contributing to new mobility, urbanization, miniaturization & lifestyle challenges

GLOBAL SUPPLY AND SERVICES

…to serve growing future markets and applications globally

ENGINEERED MATERIALS

FOR A BROAD BASE OF APPLICATIONS

PRODUCTS

- Extensive standard and customized **PA6** and **PA66**
- Specialties based on **PA6.10 and PA-HT**
- Enhanced performance compounds
- Leader in **sustainable polyamides**

SOLUTIONS FOR

- Lightweight
- Electrification
- CO2 reduction
- Miniaturization
- Eco-design

AUTOMOTIVE

INDUSTRIAL & CONSUMER GOODS

ELECTRIC & ELECTRONIC

DOMO ENGINEERED MATERIALS

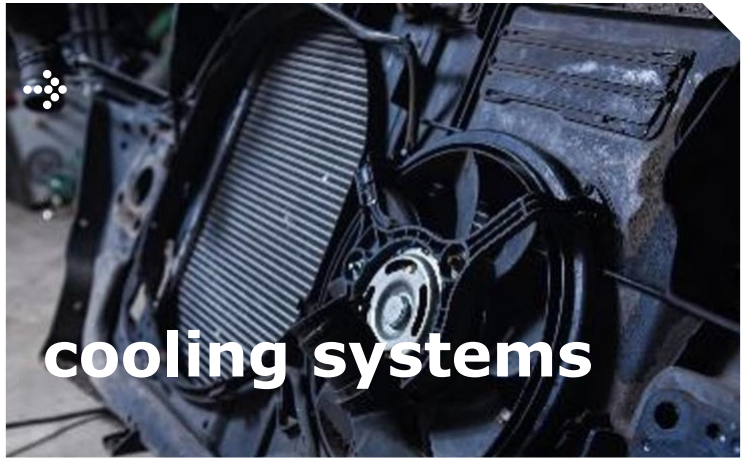
Capacity: 200kT

Recycled material sales (% of 2020 sales volume): 10%

Production units :
Germany – Italy – France – Poland - China – USA - India.

Brand names: TECHNYL® – TECHNL® 4EARTH®

WE OFFER **POLYAMIDE COMPOUNDS** FOR...



WHERE DOMO POLYAMIDES **HELP TO SAVE WEIGHT**

EXAMPLES FOR METAL REPLACEMENT IN AUTOMOTIVE APPLICATIONS

EXAMPLES

Center Console

Door Lock Mechanism

Battery Carrier

Windshield frames

Engine Mount

Oil Pan

Cross Beam

Seat Pan & Seating Structure

Timing Chain Guides and Tensioners

BENEFITS OF **POLYAMIDES**

1. **Thermoplastic semi-crystalline material with easy processing**
2. **High mechanical performance in durability and strength**
3. **Good thermal stability from -40°C to 220°C**
4. **Resistance against many chemicals**
5. **Global availability – no single sourcing**
6. **Balanced cost-to-serve ratio**

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DOMO'S INTEGRATED CONCEPT

LINKING MATERIAL AND INNOVATION

MATERIAL DATABASE & SCIENCE

DESIGN OPTIMIZATION

Function integration, topological optimization, mold design support

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SOFTWARE SIMULATION

Advanced predictive simulation to get numerical validation of a new design

FUNCTIONAL PROTOTYPING

Additive manufacturing of functional prototypes ready to be tested

APT DOMO SERVICES

APPLICATION PERFORMANCE TESTING

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

SINTER LINE® DOMO SERVICES

DOMO'S DEMONSTRATORS FOR FEASIBILITY STUDIES

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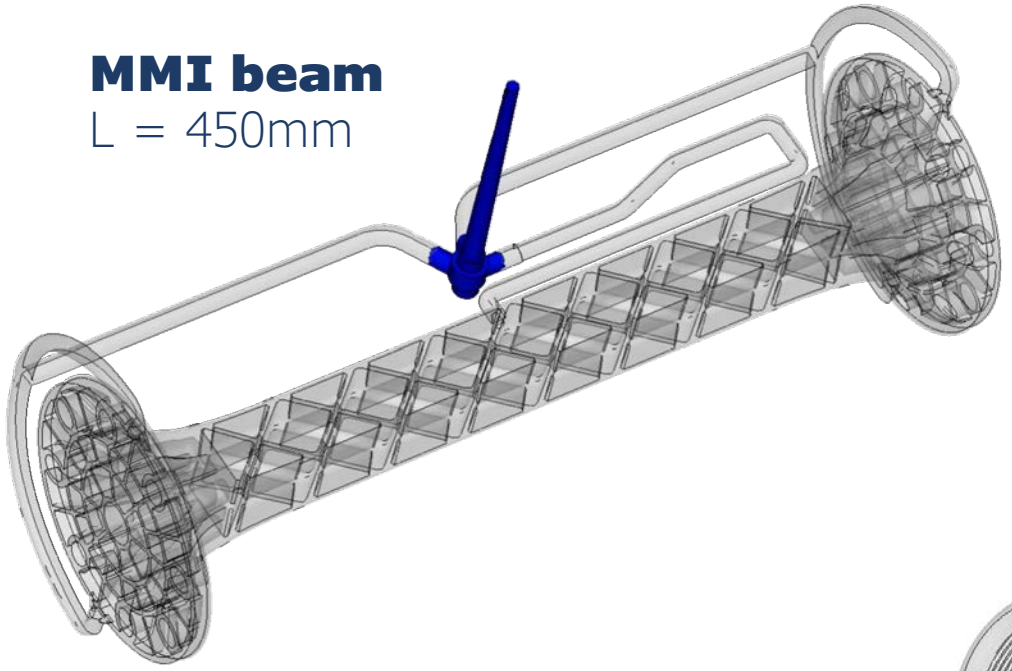
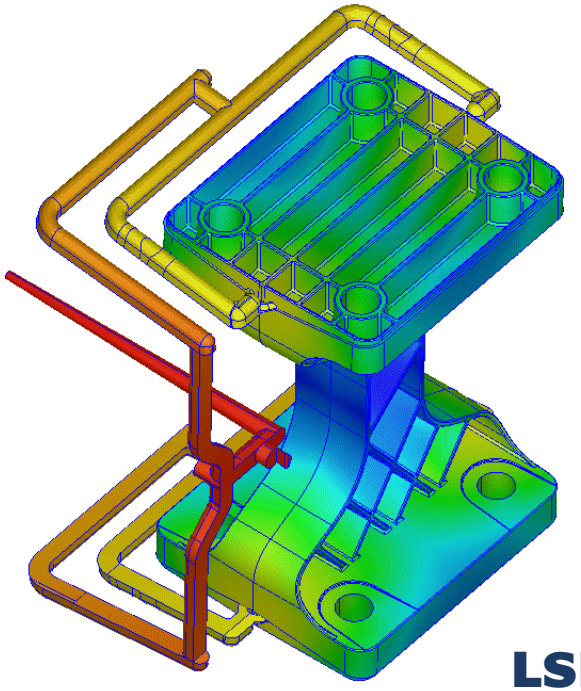
DOMO'S DEMONSTRATOR MOLDS

FOR GENERAL MECHANICAL PERFORMANCE TESTING

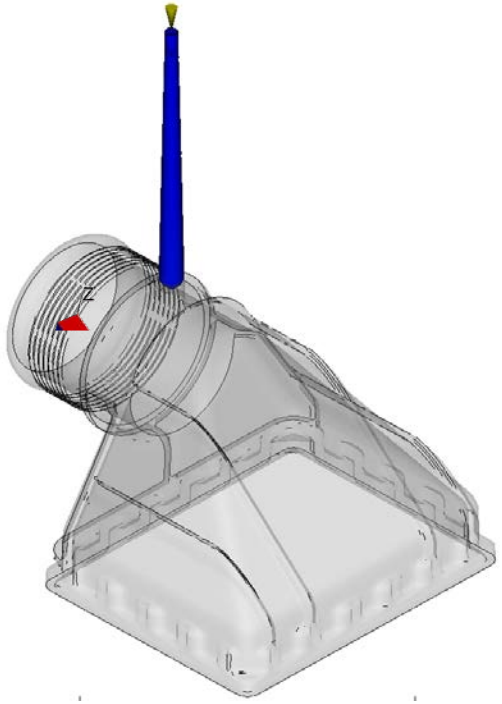
MMI beam
L = 450mm





LSD beam
L = 210mm

CAC tank
L = 130mm



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DOMO'S DEMONSTRATOR MOLDS

CREATING A DEMONSTRATOR FOR WELDED PARTS

What are the benefits of having a demonstrator for welded part?

Real use-case assessment for hollow parts like manifolds, pipes, ducts, valves, …:

- Single side / cross flow media ageing
- Internal pressure testing

Studying relevant injection molding effects:

- Meltlines of different angles

Assessing vibration welding itself:

Linear vibration welding processes

Alternative welding technologies like hot plate or hot gas welding

Prove of design and simulation process:

- Validation of numerical simulation models

Creating a 360° view for accelerated material development

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DOMO'S DEMONSTRATOR MOLDS

OUR DEMONSTRATOR FOR WELDED PARTS

Molded part with runner system

Vibration welded assembly

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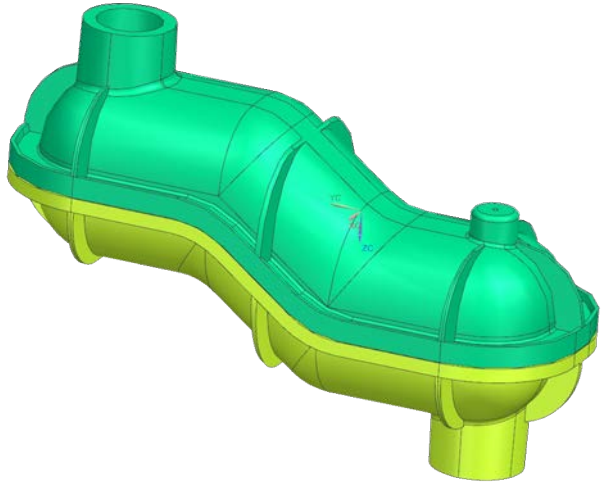
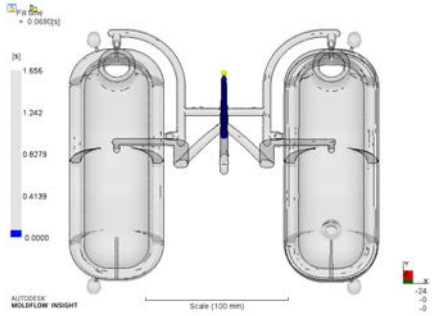
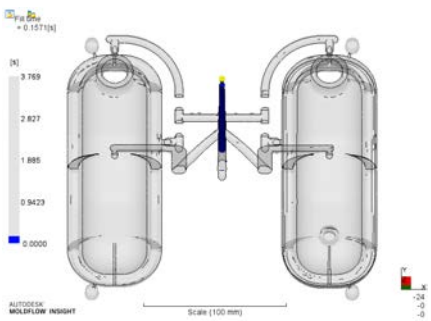
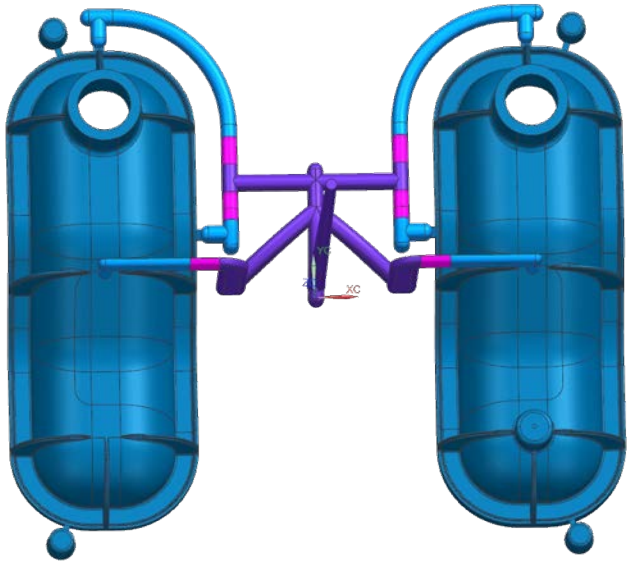
DOMO'S DEMONSTRATOR MOLDS

MULTIPLE GATING OPTIONS FOR DESIGN OF EXPERIMENTS

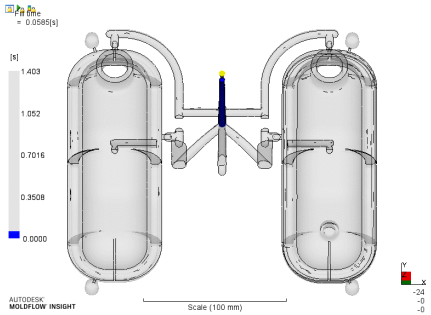


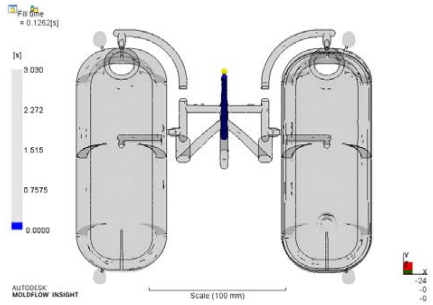


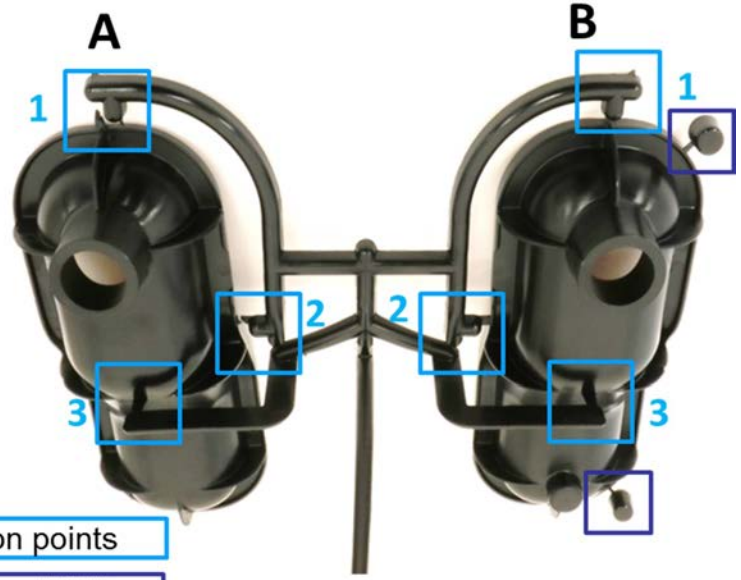




7 injections configurations to move weldlines areas and fibers orientations







Injection points

Overflow Well

USAGE OF THE WELDING DEMONSTRATOR IN COOLANT AND AIR

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DOMO'S DEMONSTRATOR MOLDS

MULTIPLE TESTING OPTIONS FOR DIFFERENT EXPERIMENTAL STUDIES

Burst pressure test with air

AIR

Test case for CAE simulation

Media short- and long-term testing

COOLANT

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[Maxime Le Corre]

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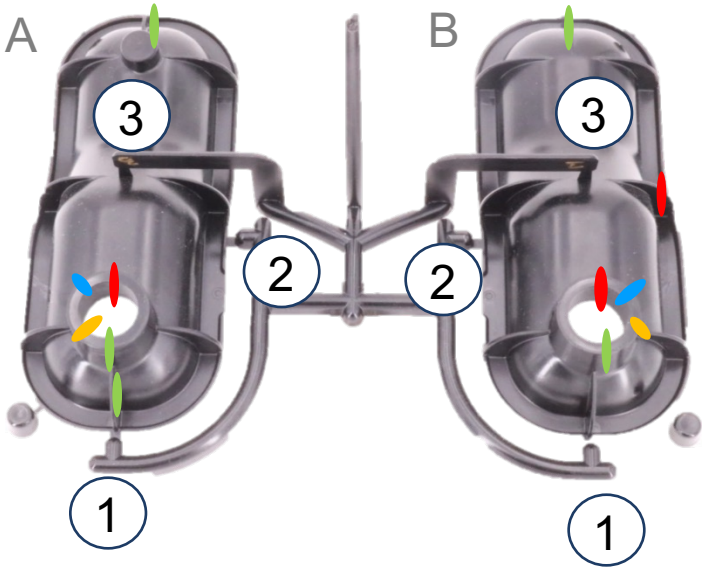
DOMO'S DEMONSTRATOR MOLDS

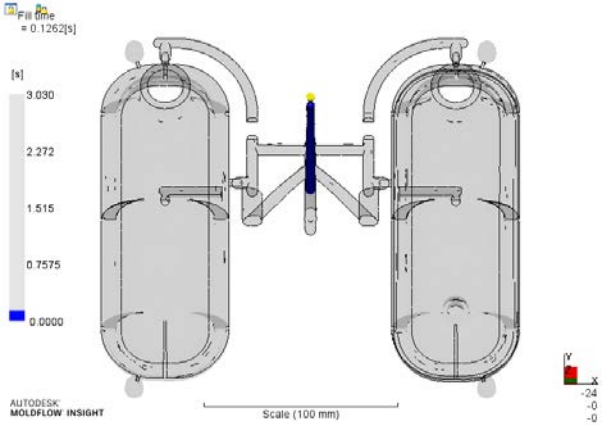
TEST EXAMPLE: WORKMANSHIP ("COOKING") TEST

Material	Molding configuration	Crack presence
Various polymers possible	A1 – B1	+ + +
	A2 – B2	+ + +
	A3 – B3	+ +
	A123 – B123	+

48h at 135°C in pure glycol

Molding configuration + crack localization





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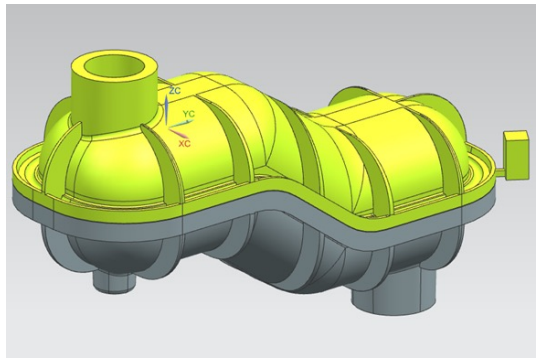
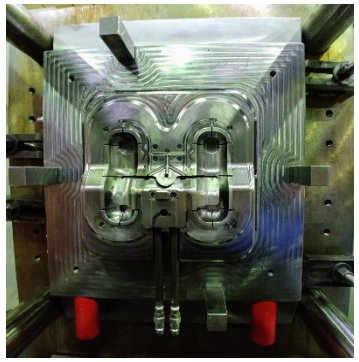
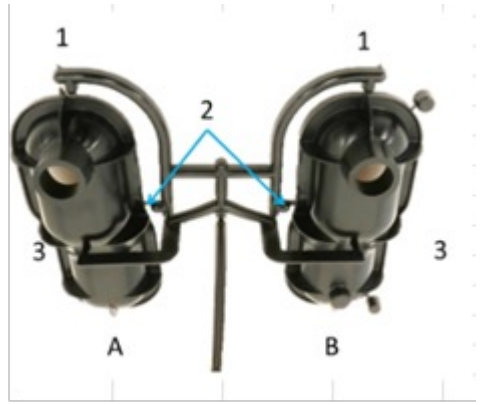
DOMO'S DEMONSTRATOR MOLDS

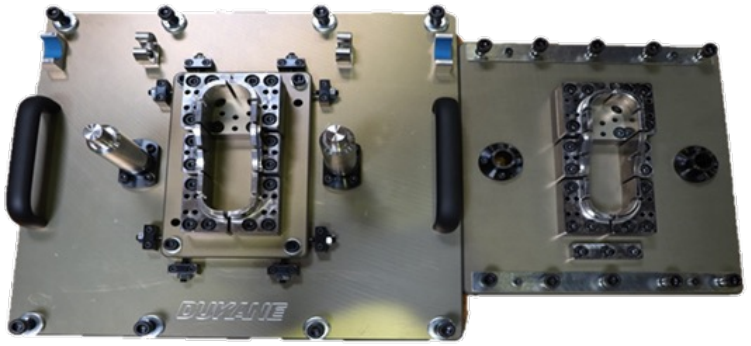
TEST EXAMPLE: LONG TERM COOLANT AGEING OF WELDED PARTS



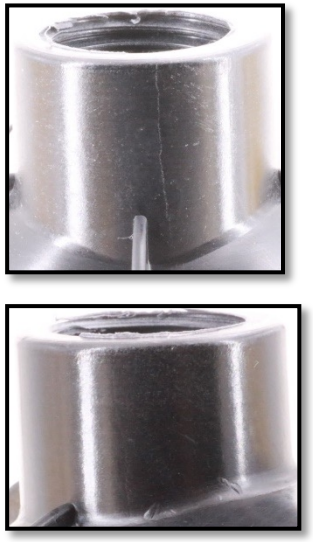


Mold with different gating configurations





Cooking test



Material benchmarking after ageing

Burst test DAM and after cooking test

1500h – 135°C coolant ageing

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SIMULATION OF VIBRATION WELDED PARTS

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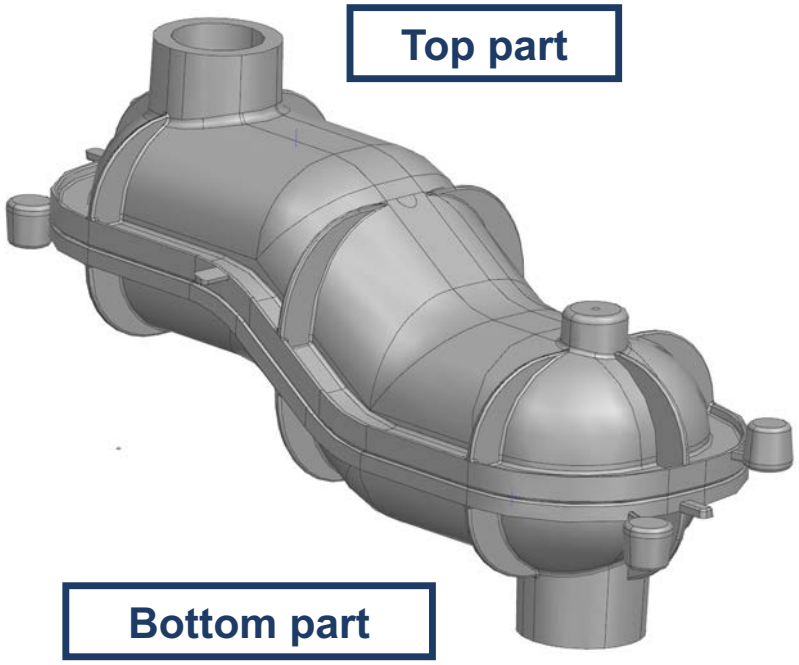
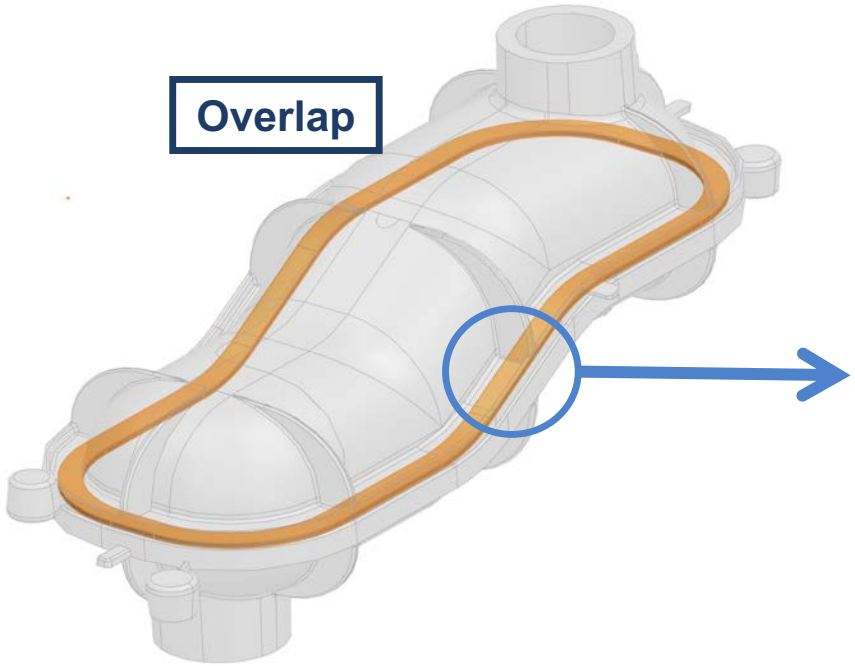
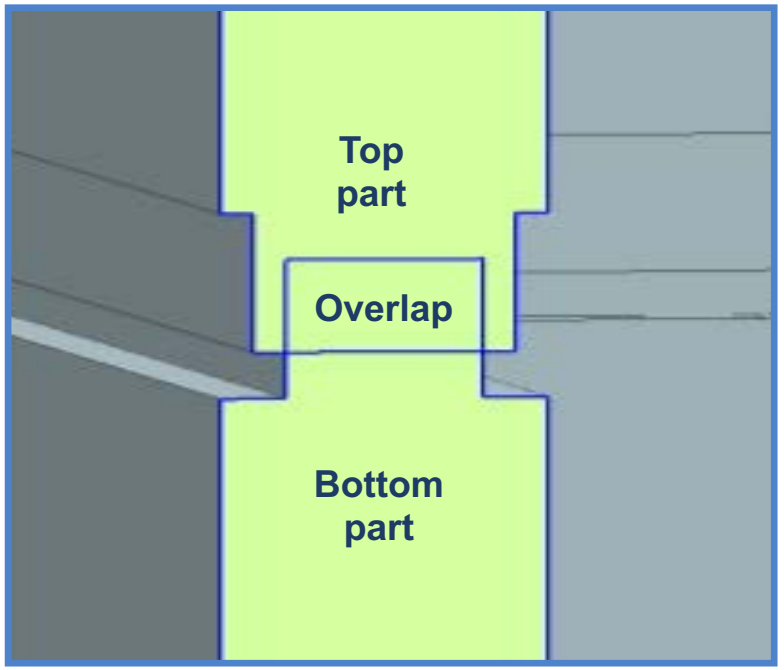
SIMULATION OF VIBRATION WELDED PARTS

DESIGN ANALYSIS AND PREPARATION OF WELDED CAE MODELS







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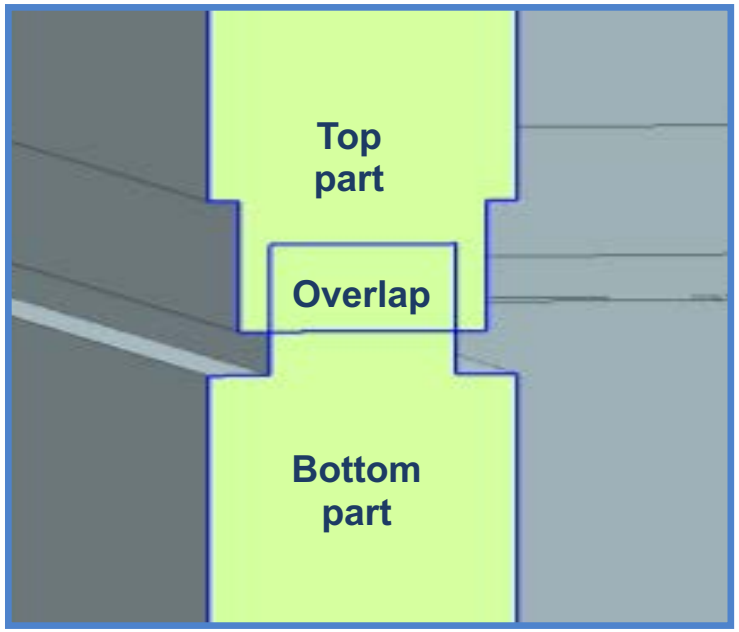
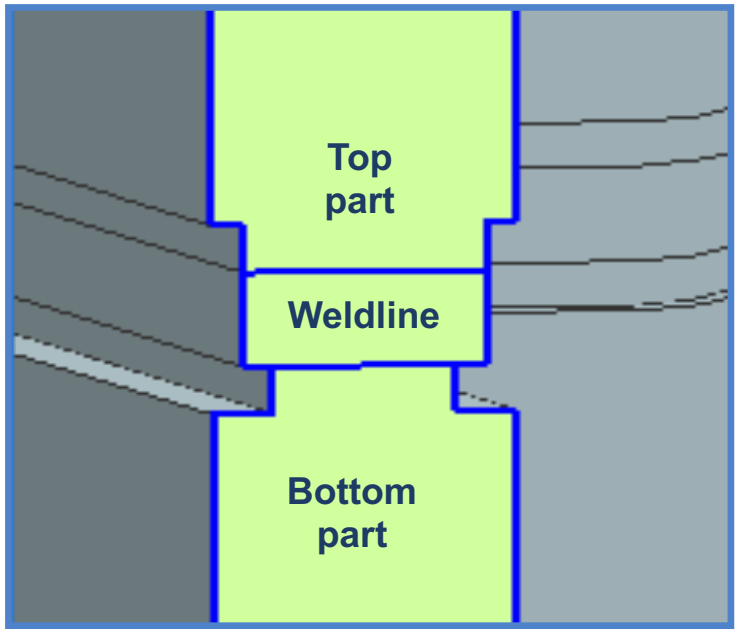
SIMULATION OF VIBRATION WELDED PARTS

DESIGN ANALYSIS AND PREPARATION OF WELDED CAE MODELS



From overlap to weld line

Weldline and weld flash to be represented in simulation according to weldline design and process



Representation of the weldline in CAE simulation:

- Same material – only different GF-orientation
- Advantage: All material models including failure can be used

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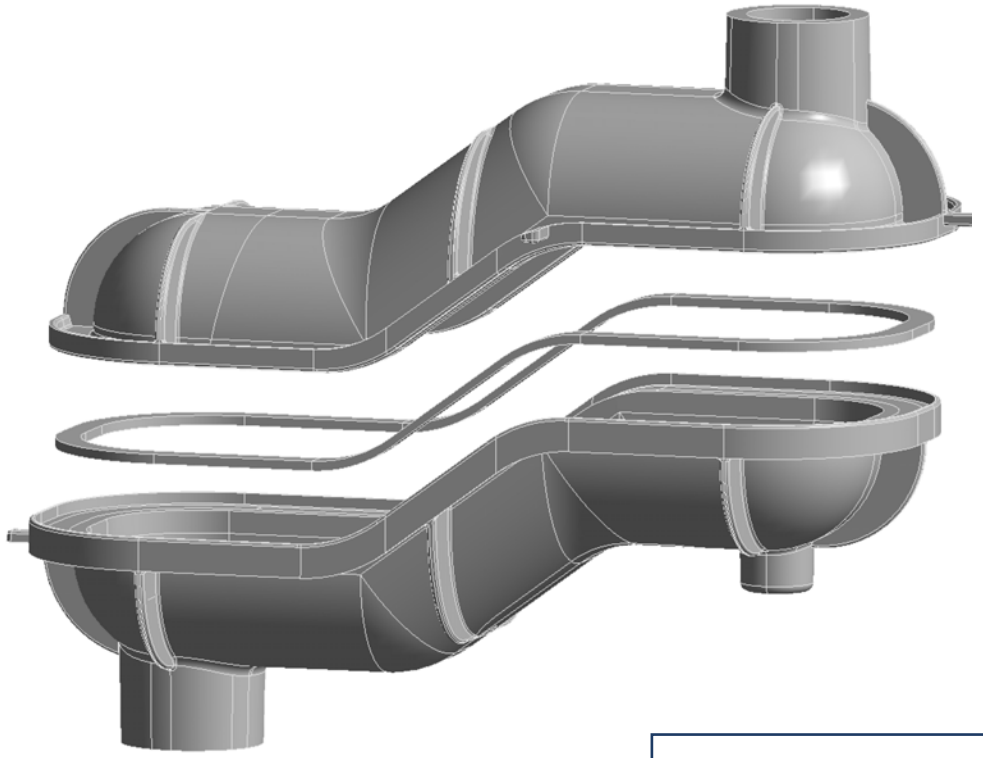
SIMULATION OF VIBRATION WELDED PARTS

GENERAL PROCESS FLOW OF INTEGRATED STRUCTURAL MMI SIMULATION



- Identify relevant molding parameters and test conditions
- Run injection molding simulation and extract GF-orientation tensors
- Create 2D GF-orientation tensor for weldline
- Combine 3D-geometries, boundary conditions and GF-orientation dependent material model in integrated structural MMI simulation

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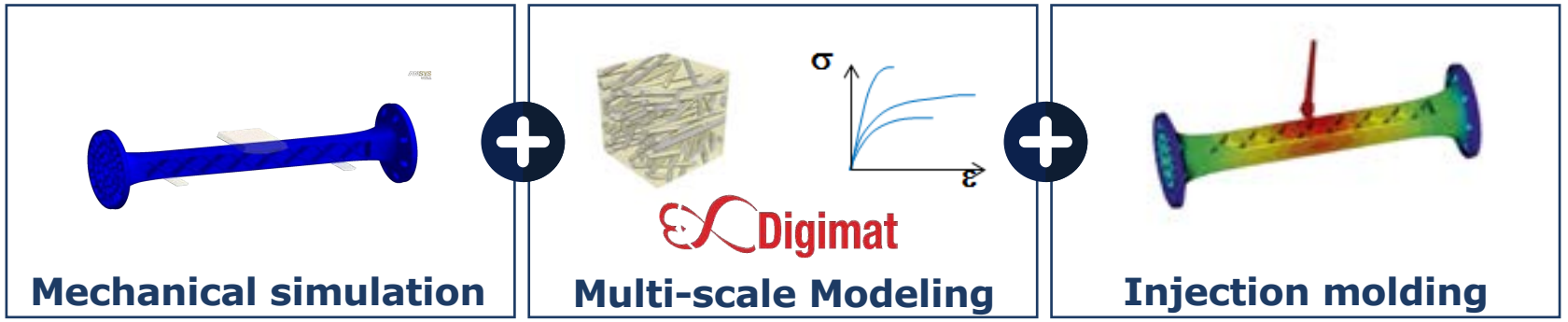

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MMI™ TECHNYL® DESIGN

THE MOST EXHAUSTIVE AND RELIABLE DATABASE OF DIGIMAT MATERIAL CARDS

34 900+ analysis files for 77 grades

- **Multiple material behavior**
- **3 matrix: PA6, PA66, PA-HT**

Temperature

-40 to 210°C

EH

0% to 100%

GF

15% to 60%

- **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)
- **Modals, Vibration and 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

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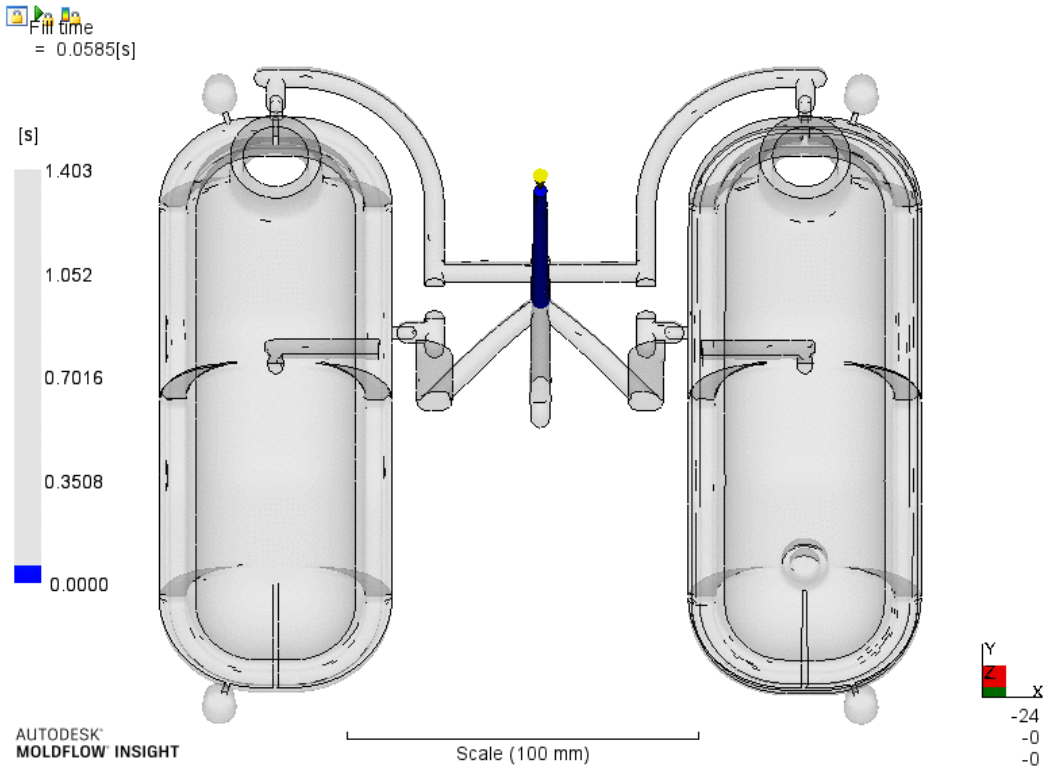
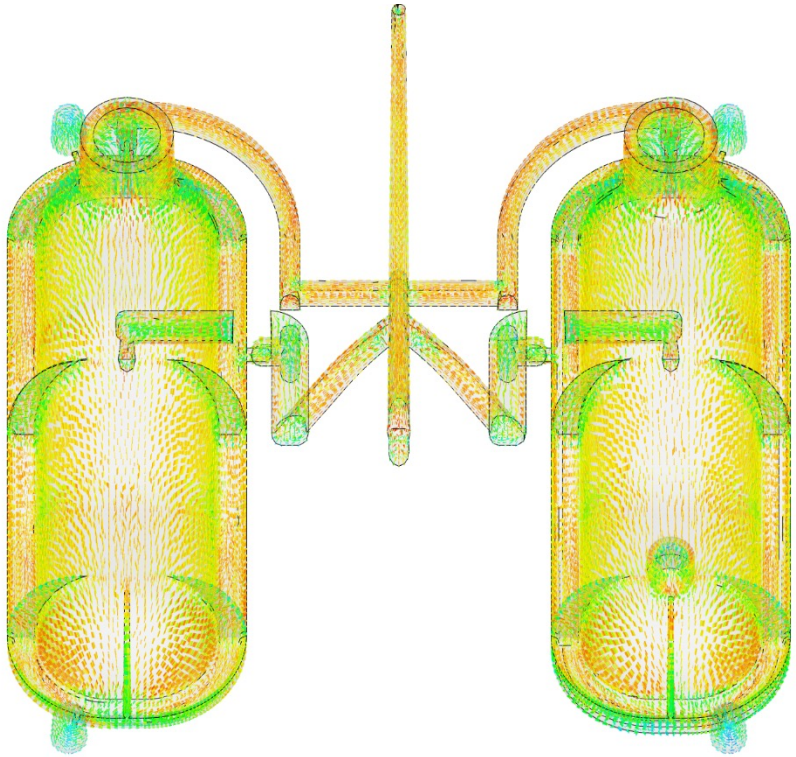
SIMULATION OF VIBRATION WELDED PARTS

STEP 1: MOLDFLOW SIMULATION AND EXTRACTION OF GLASS FIBER ORIENTATIONS





Filling and packing simulation

Resulting GF orientation is basis of integrative structural simulation with anisotropic material data

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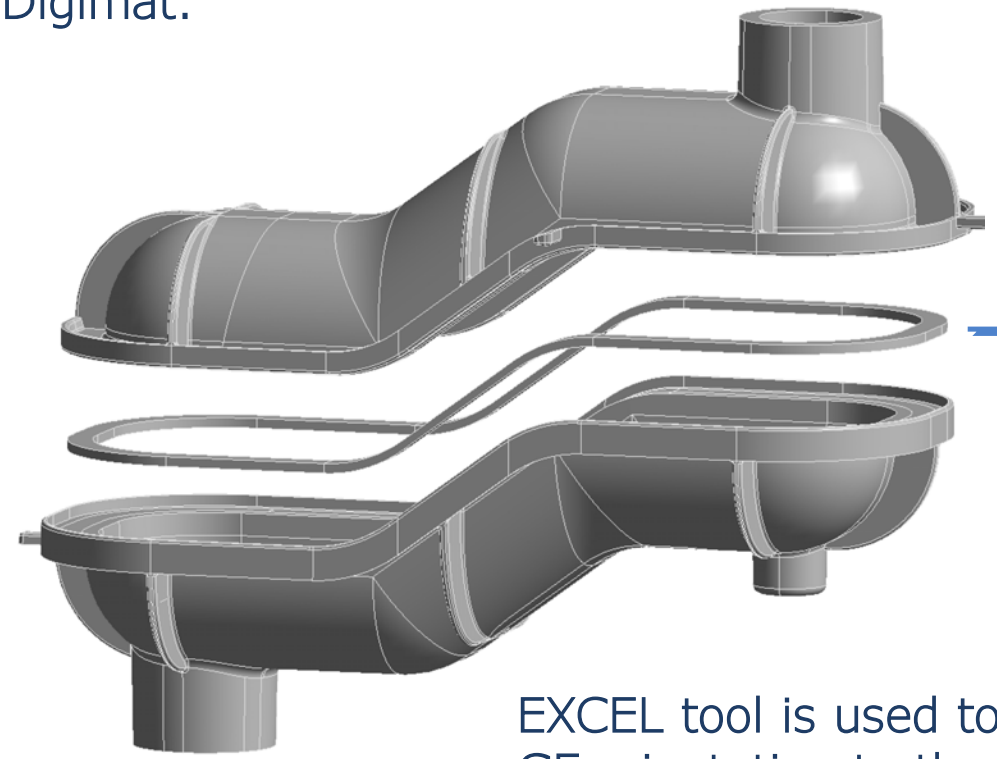
SIMULATION OF VIBRATION WELDED PARTS

STEP 2: ASSIGNING LOCAL ANISOTROPIC MATERIAL DATA

Automatic mapping and assignment of GF orientation dependent material data in Digimat.



EXCEL tool is used to assign GF orientation to the weld line area

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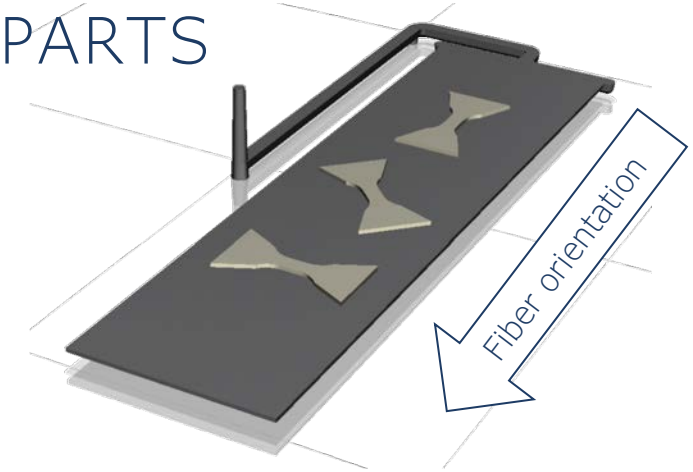

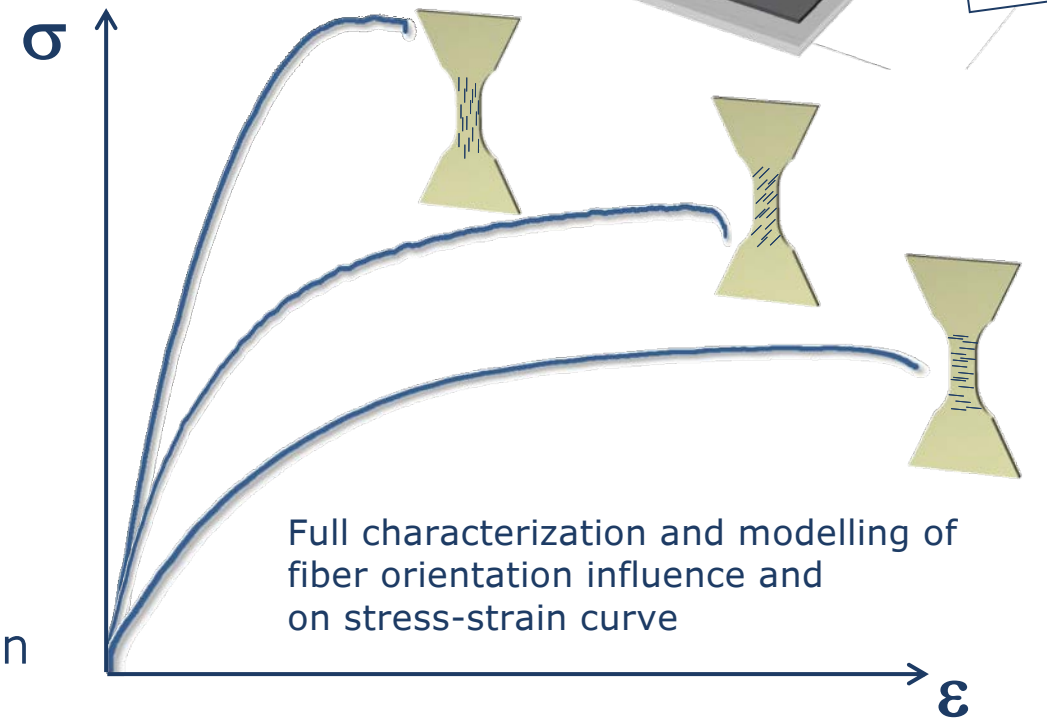

Full characterization and modelling of fiber orientation influence and on stress-strain curve

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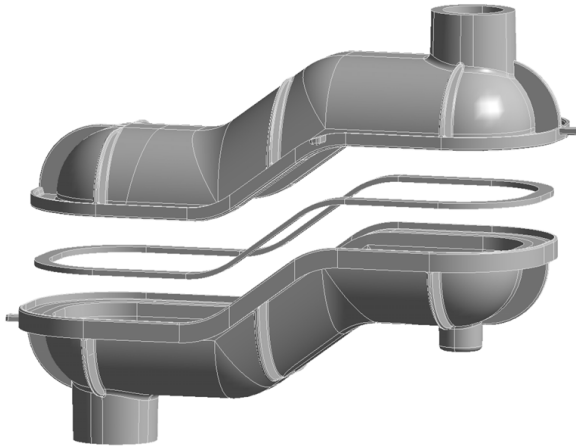
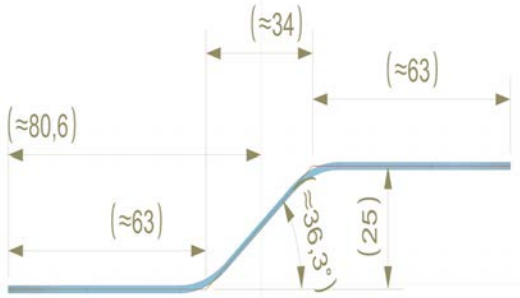
SIMULATION OF VIBRATION WELDED PARTS

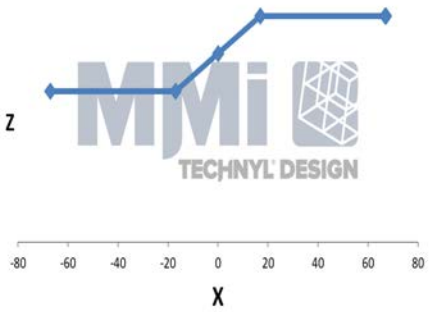
STEP 3: DEFINING THE GLASS FIBER ORIENTATION IN THE WELDLINE





.pat File Path	C:\DATA\Formation_etude_test\3-Tensor\version2\weld.pat
.xml File Path	C:\DATA\Formation_etude_test\3-Tensor\version2\weld.xml

Zone Number	X		Angle (°)
	From	To	
1		-17	0
2	-17	0	36.3
3	0	17	36.3
4	17		0



Tensor for local coordinate

Tensor	1	2	3
1	0.5	0	0
2	0	0.5	0
3	0	0	0

EXCEL file allows to define two types of weldlines:

- Uniaxial vibration welding
- Rotational vibration welding

Glass fiber orientation assigned as “2D-random” in the weldline

No voids or other material effects considered

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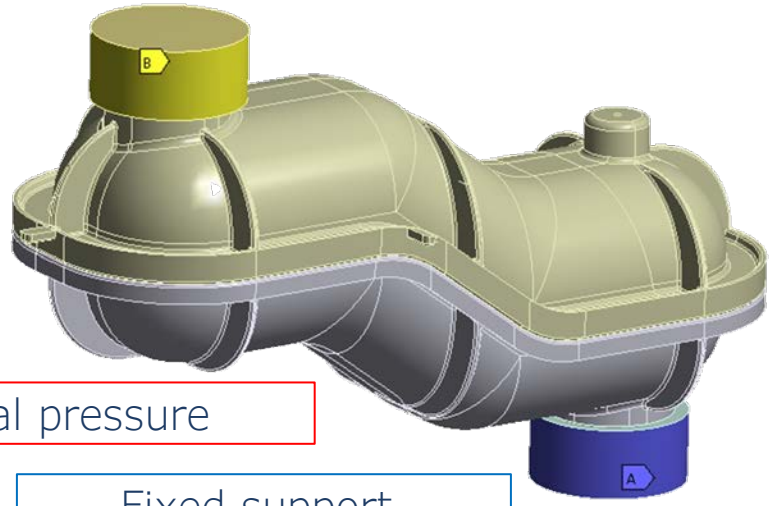
SIMULATION OF VIBRATION WELDED PARTS

STEP 4: PREPARING AND RUNNING THE MECHANICAL STRUCTURAL SIMULATION

T = 23°C
50% rel. humidity

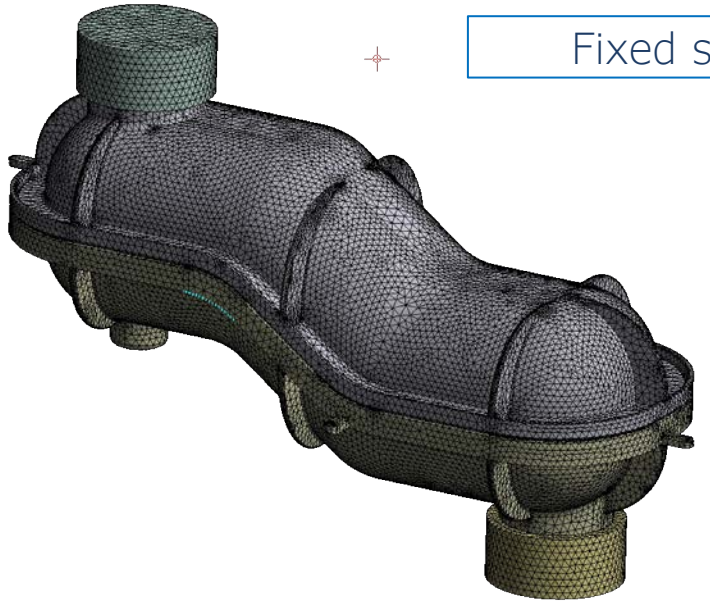
Material: Technyl A 218 V50 bk 21N (PA66-GF50)

Connections closed



Internal pressure

Fixed support



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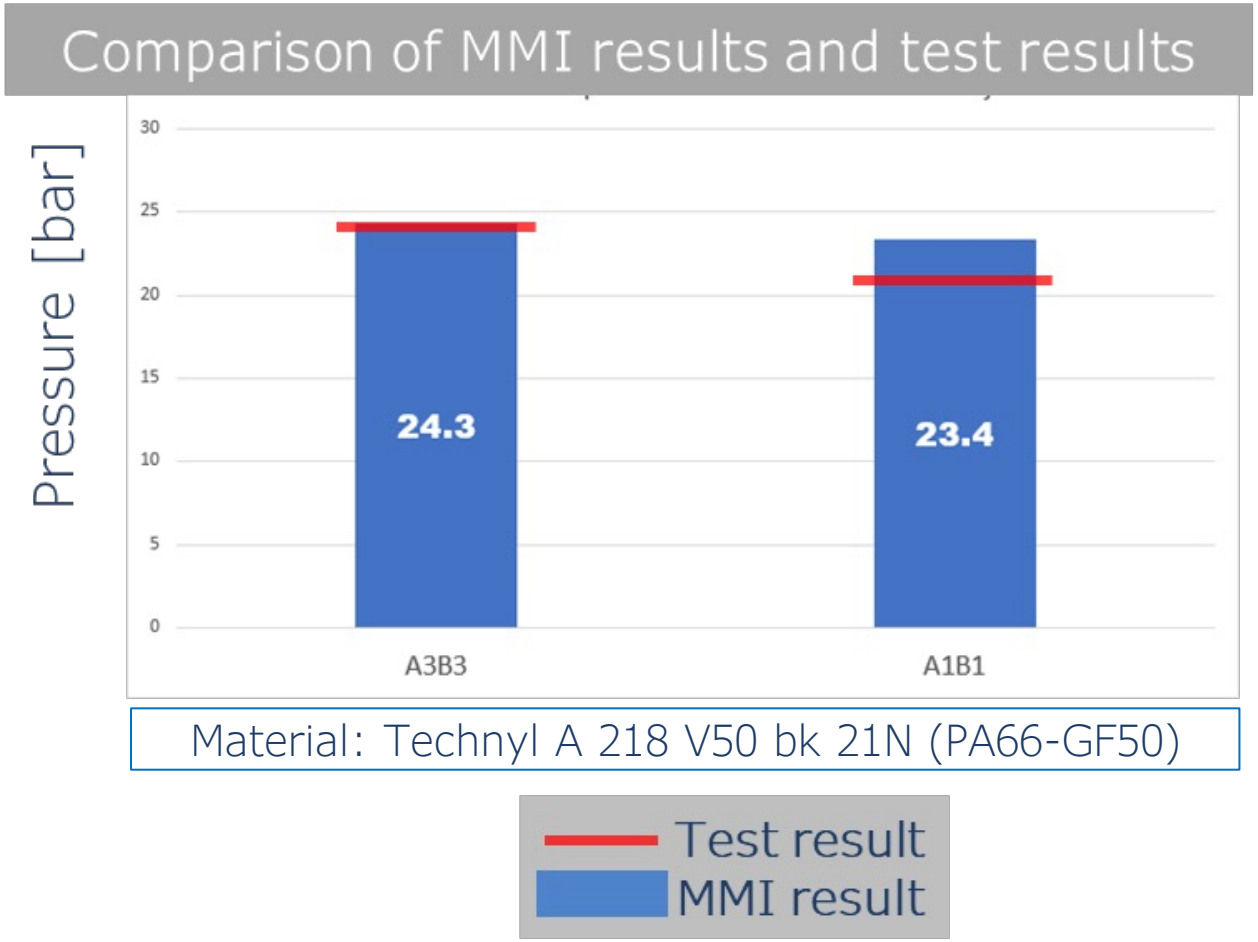
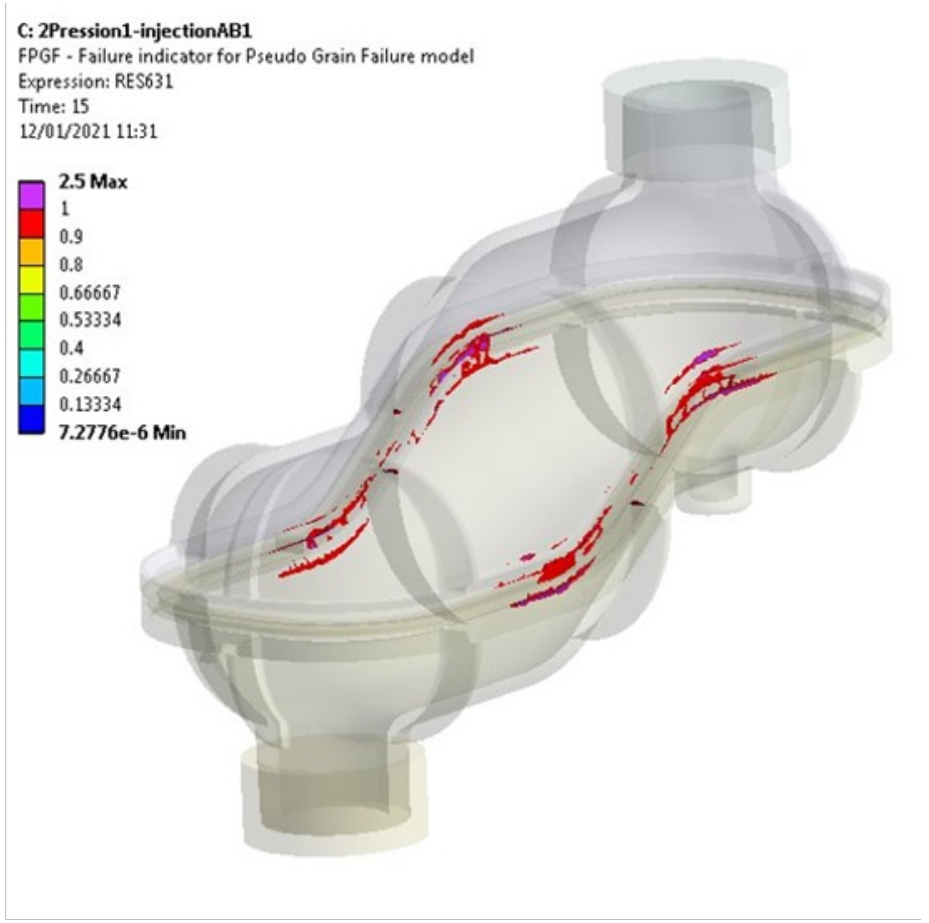
SIMULATION OF VIBRATION WELDED PARTS

STEP 5: SIMULATION RESULTS AND TEST CORRELATION





Failure near weldline area

CONCLUSIONS

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JOINING TECHNOLOGY AT ITS BEST

SUMMARY

- **DOMO's can provide a wide set of PA compounds** with tailored properties each application
- **Our materials come with detailed mechanical data** needed for the prediction of the part's performance.
- The unique TECHNYL HUB brings **the full service from design, simulation and part testing.**
- In the example part **simulation and testing of welded parts was shown**.
- **Good correlation between simulation and test** has been reached.
- This can support further customer developments building a basis for straight-forward **design approach with ideal cost-to-serve ratio.**

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Q&A SESSION

DOMO

Equipping our partners for innovation and sustainability through unparalleled expertise in polyamides

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Simulation Customer Support Manager

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E-mail: wido.ziemer@domo.org

OUR **AMBITION** AT **YOUR SERVICE**

Q&A

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K-SHOW 2022

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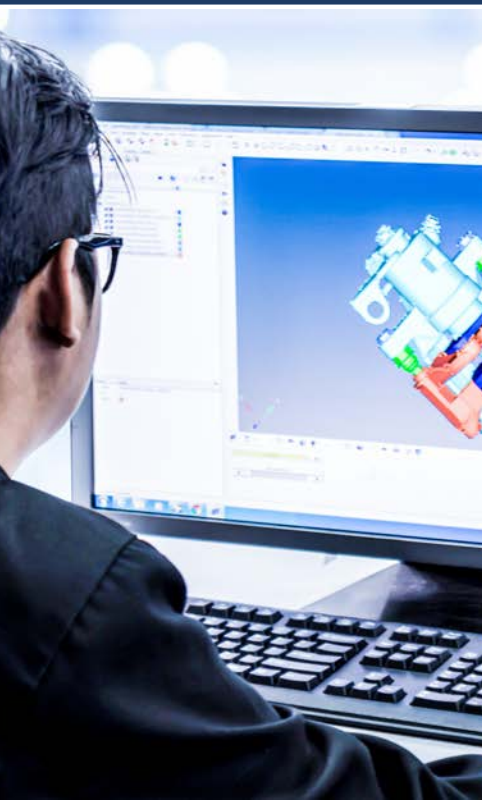

DOMO

caring
is our formula

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