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Virtual Up Scaling

HUMANITY AT WORK MONDRAGON

Agenda

1. Introduction to Leartiker
2. Experimental testing and FEA correlation of automotive structural components

BACKGROUND

- Polymer engineering services with 20 year experience in different sectors:
  - Automotive
  - Health

- Belongs to a international group: Mondragon.
  - 11.875 Milions € total revenue.
  - 260 centers.
  - 74.000 Jobs worldwide.

- 25 highly qualify professionals (PhD., Msc., Ing., Bachelor in Chemistry)

Customers

cikautxo GROUP

BATZ

MAIER

KauTenik

Ercros

REINER

CIE Automotive

PolyOne

Indar An Ingeteam brand

ALBIS

BEFESA

Mando

PMG passion for mobility

edai

inauxa

orkli

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Material and components Testing

- Dynamic and fatigue testing
- Impact testing
- Wide Tª testing range (-70/180 ºC)
- High speed cameras recording

Components development (Coengineering)

- Material definition and selection
- Initial CAD design.
- Conceptual prototype.
- MoldFlow/Digimat/Ansys simulation.
- Final CAD model
- Soft Mold (Metallic)
- Samples injection trials
- Testing of samples
- PPAP for samples
- Injection parameters

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Experimental testing and FEA correlation of automotive structural components.

Use of DIGIMAT and a specific methodology for short fiber reinforced polyamides.

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Motivation.

- fiber reinforced thermoplastic materials are being extensively used in load carrying applications.
- automotive sector is especially interested in weight saving materials in order to reduce emissions.
- component suppliers need to design, in short development times, parts that fulfill with requirements in terms of performance, costs and weight savings.
- as a research and technical center, Leartiker needs to supply specific testing and simulation methodologies in order to help customers developing products.
  - ***<u>a big goal is to include manufacturing effects when simulating structural loads in fiber reinforced thermoplastics made components.</u>***

Objective

- Use the right design procedure to design with anisotropic materials

- Improve correlation % between experimental and simulation (5% in modulus).

- Not to overestimate part geometry

Material

- PA6-GF40 from DSM, AKULON K224HG8.
  - short fiber reinforced Polyamide 6.
  - 40% mass fraction glass fiber.
  - heat stabilized.
- this is a usual material for manufacturing automotive clutch pedals.
- DSM provides some mechanical data both in the web site www.dsm.com and in the CAMPUS database www.campusplastics.com

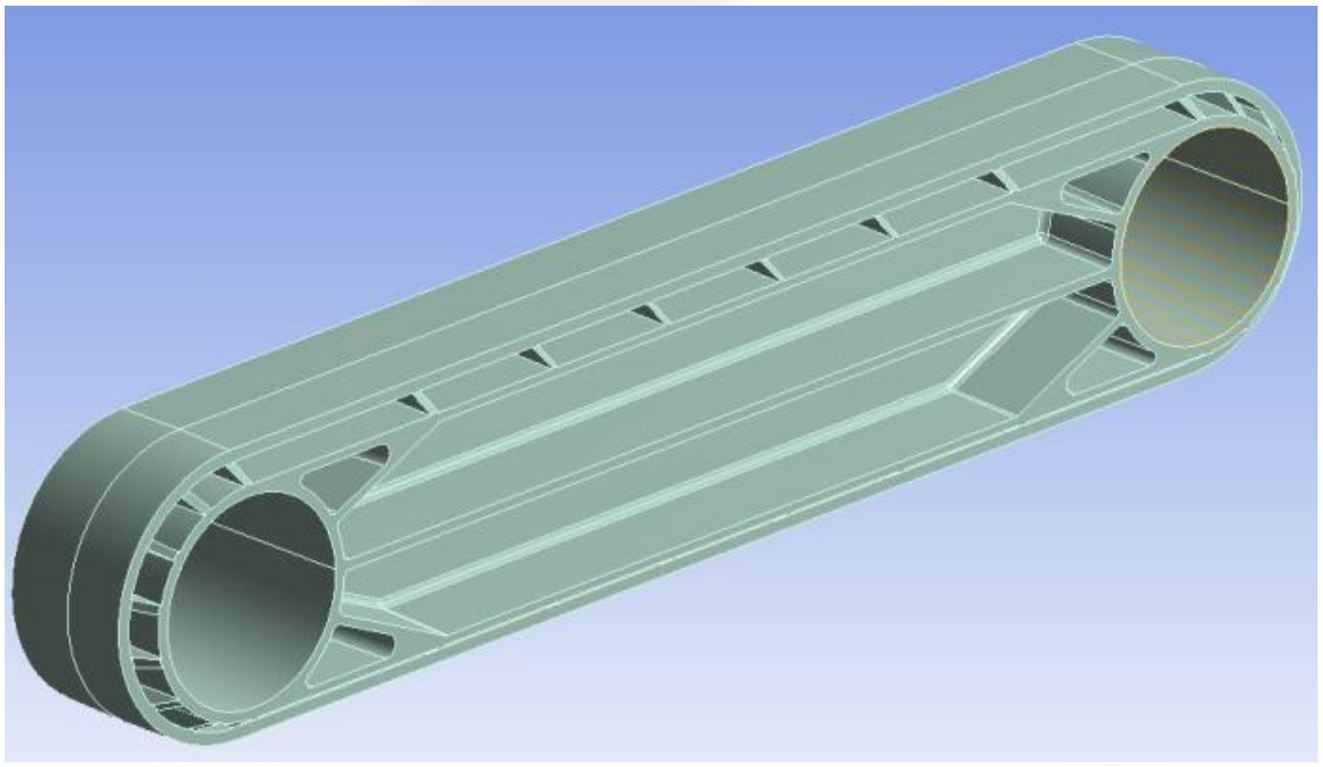
Mechanical properties	dry	cond.		
Tensile modulus	13000	8000	MPa	ISO 527-1/-2
Yield stress	*	*	MPa	ISO 527-1/-2
Yield strain	*	*	%	ISO 527-1/-2
Nominal strain at break	*	*	%	ISO 527-1/-2
Stress at 50% strain	*	*	MPa	ISO 527-1/-2
Stress at break	205	140	MPa	ISO 527-1/-2
Strain at break	3	6	%	ISO 527-1/-2
Tensile creep modulus (1h)	*	-	MPa	ISO 899-1
Tensile creep modulus (1000h)	*	-	MPa	ISO 899-1
Charpy impact strength (+23°C)	95	100	kJ/m²	ISO 179/1eU
Charpy impact strength (-30°C)	85	85	kJ/m²	ISO 179/1eU
Charpy notched impact strength (+23°C)	18	26	kJ/m²	ISO 179/1eA
Charpy notched impact strength (-30°C)	13	13	kJ/m²	ISO 179/1eA

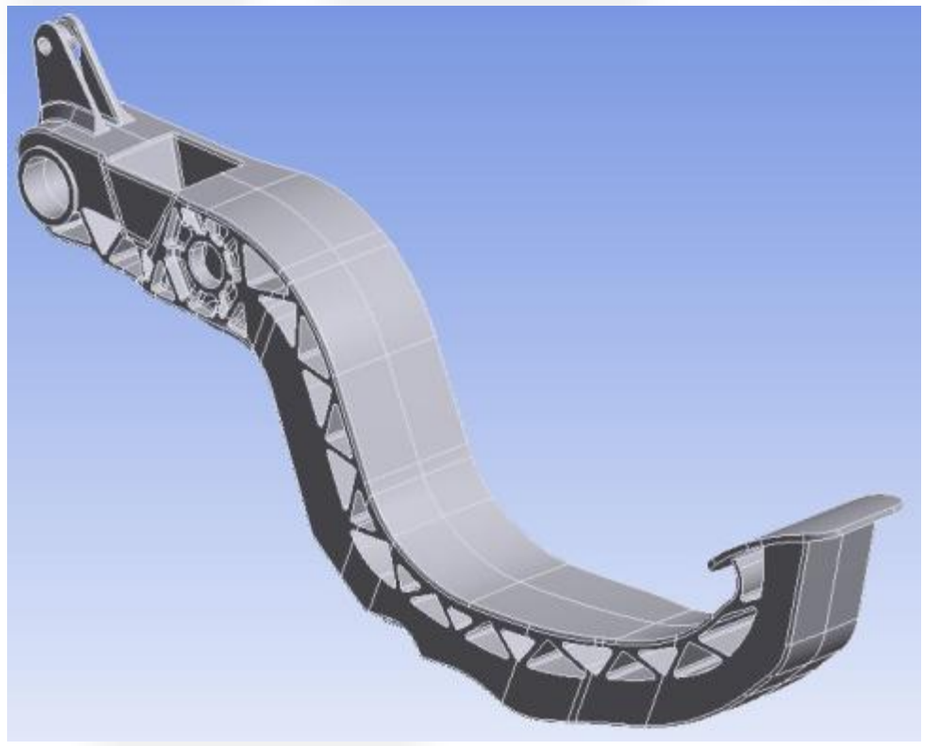
Components.

two automotive structural components were studied in this work.

clutch pedal, reference VW120 for Volkswagen.

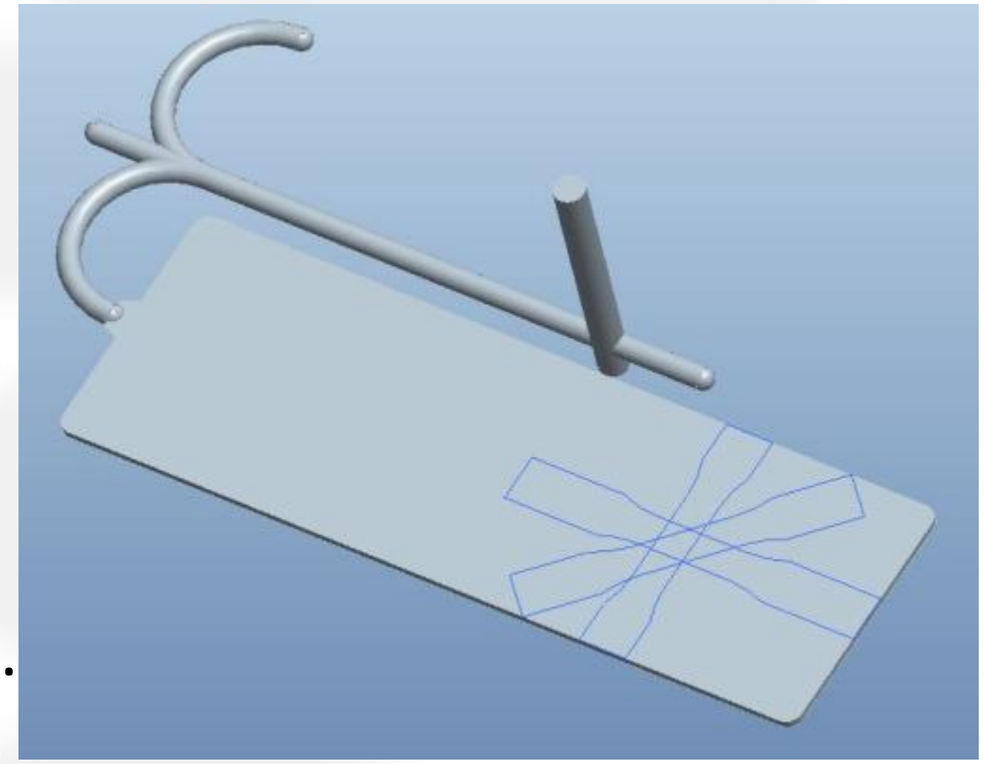
stabilizer link, for Audi.





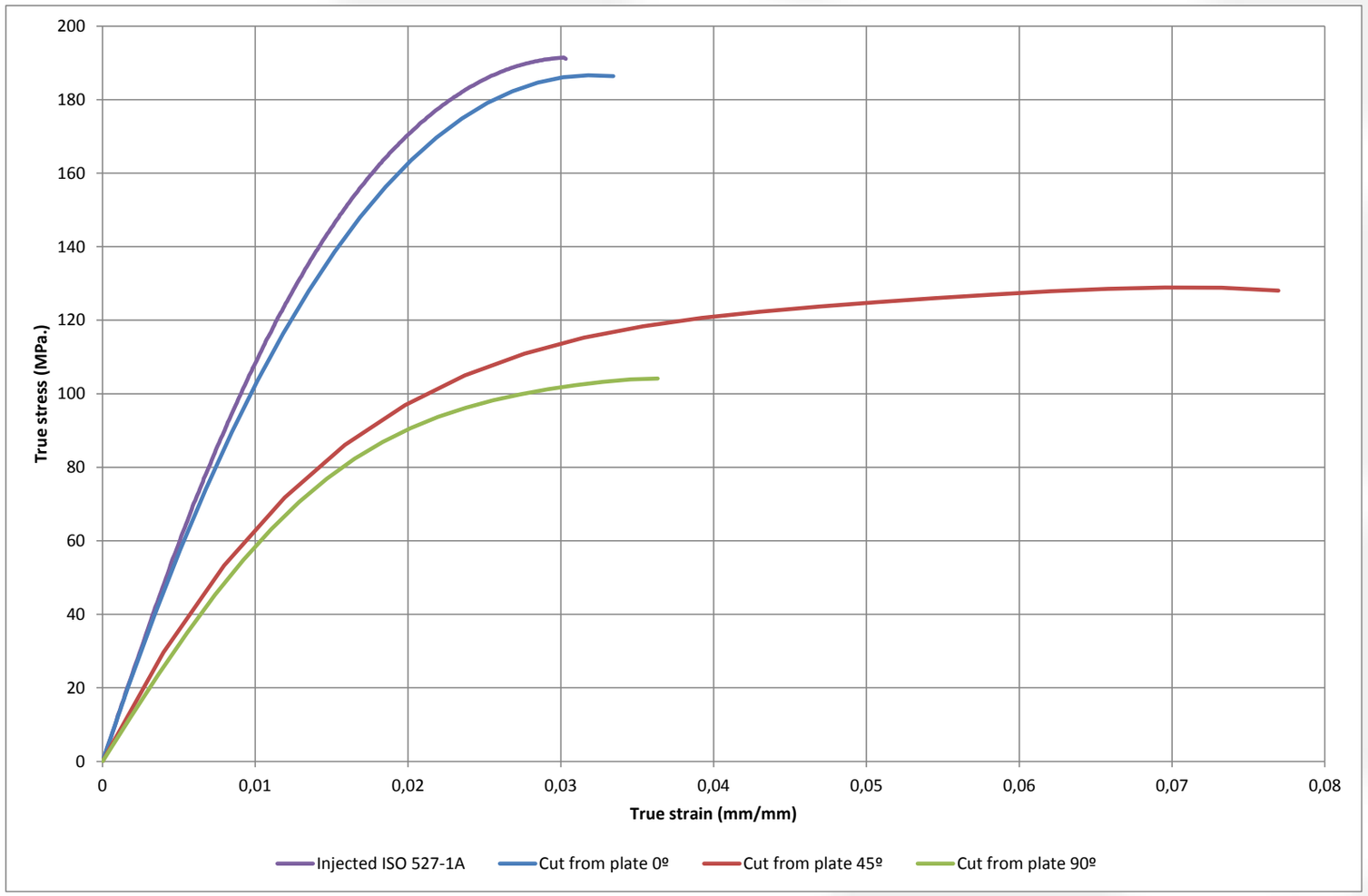
Experimental.

- anisotropic material data was generated with the use of a specific plate following guidelines from Exstream.
- the plate dimensions are 305 x 102 x 3.2 mm.
- specimens are cut with a special milling tool for fiber reinforced materials at 0, 45 and 90º.
- the plate is sufficiently large enough to assure a stabilized flow front.
- specimen dimensions are based but with reduced size in order to fit to the plate.
- σ-ε data was obtained as for ISO 527 specimens.



Experimental, results.

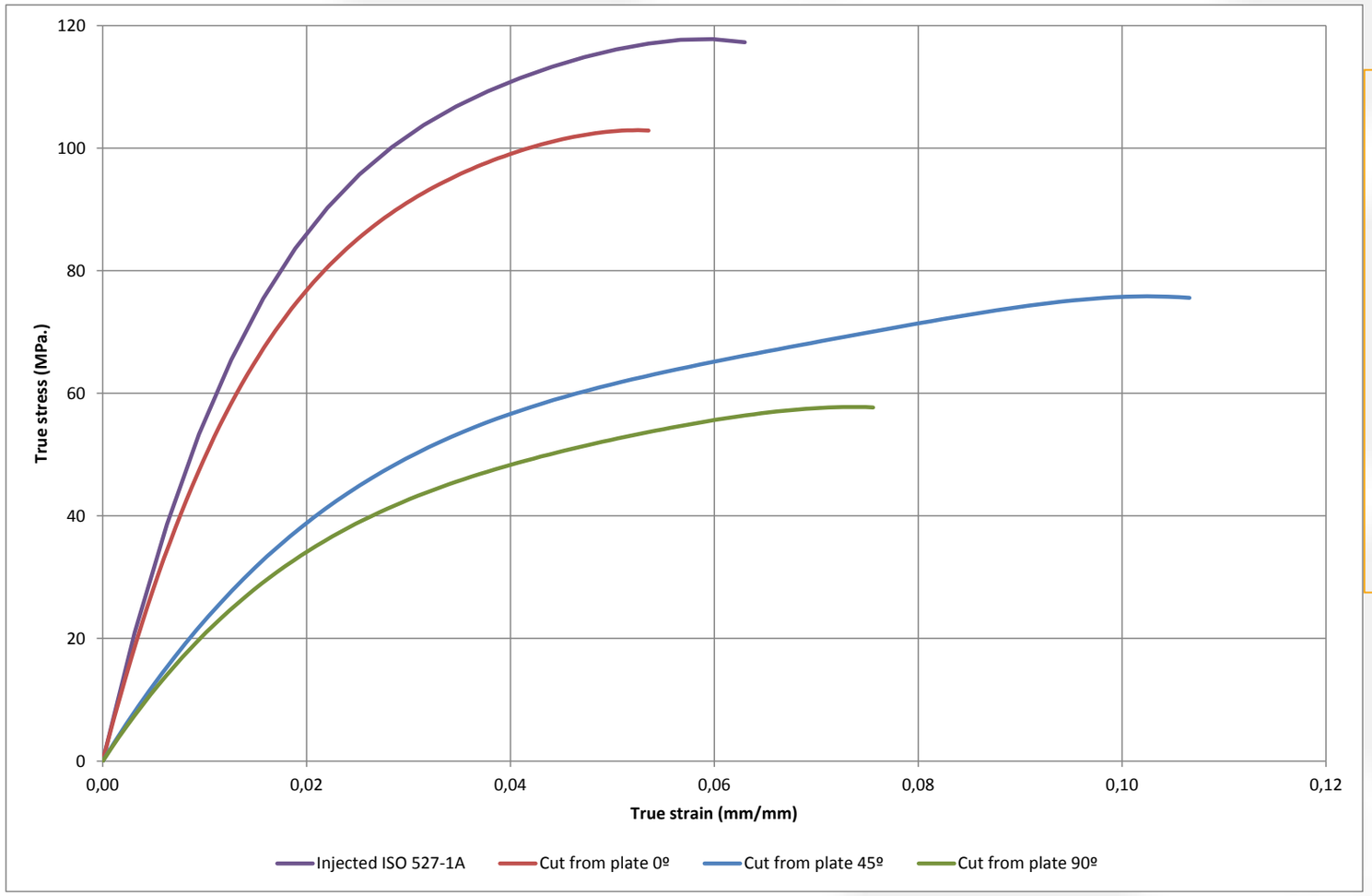
- Tensile test results, ISO 527-1A and 0, 45 and 90º. DRY



- minor difference in modulus between injected standard and milled specimens.
- 3% difference in strength.
- clear anisotropic behavior between different orientations.
- this data was checked with data provided by DSM, similar behavior, except:
  - for ISO 527-1A, DSM uses 50 mm/min, higher strengths are obtained.
  - for anisotropic data DSM uses another type of plate, for this material the distinction between 45 and 90º is not clear in that case.

Experimental, results.

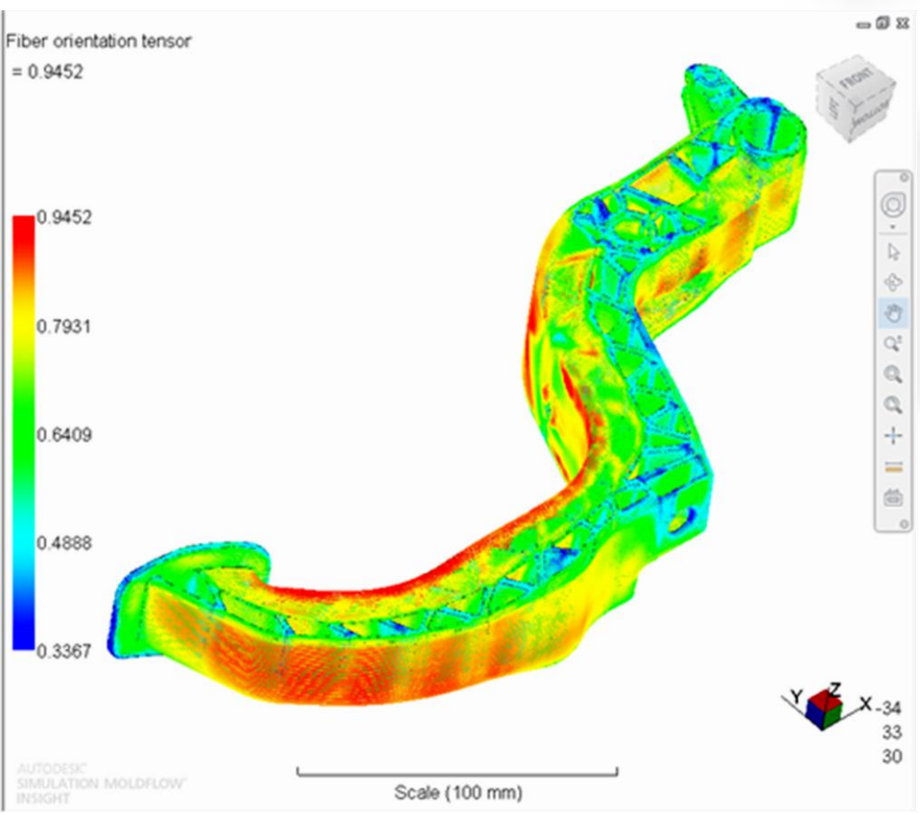
- Tensile test results, ISO 527-1A and 0, 45 and 90º. PV1200, 2.5 humidity



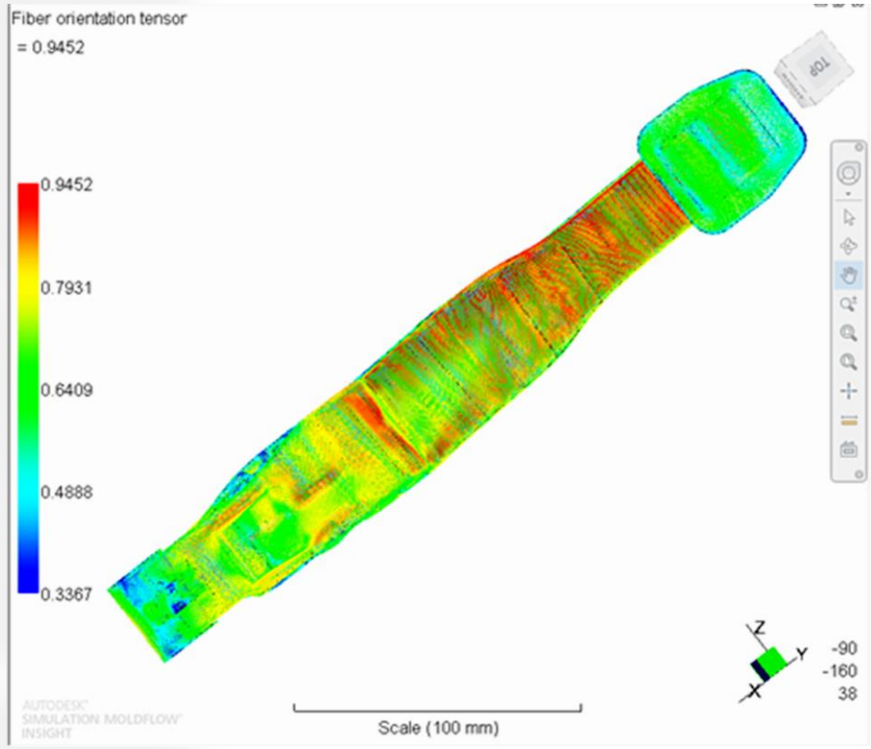
- minor difference in modulus between injected standard and milled specimens.
- 12% difference in strength.
- clear anisotropic behavior between different orientations.
- this data was checked with data provided by DSM, just for reference since the levels of humidity obtained in the material were not comparable.

Experimental, FEA.

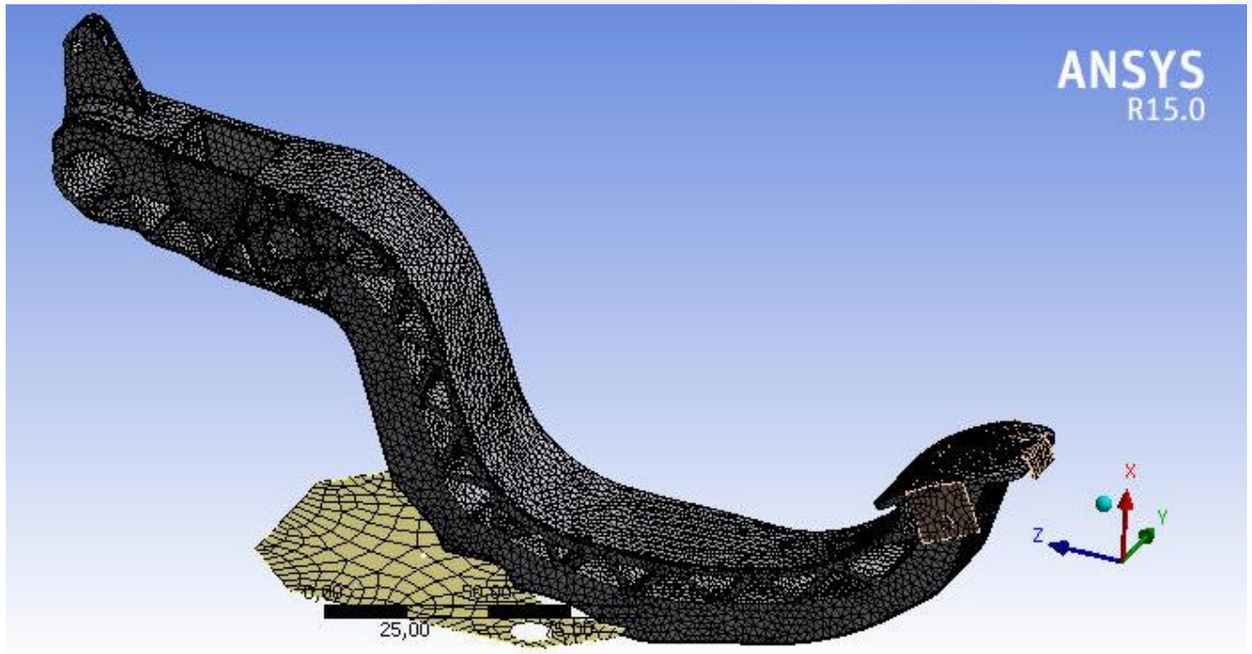
- Pedal component:
  - processing parameters used in the injection molding machine were replicated in Autodesk Moldflow® 2015.
  - fiber orientation tensor was considered to be the first order parameter to be taken into account in the coupled analyses.

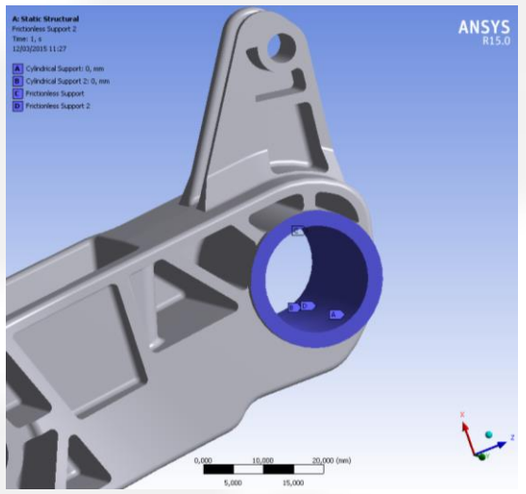


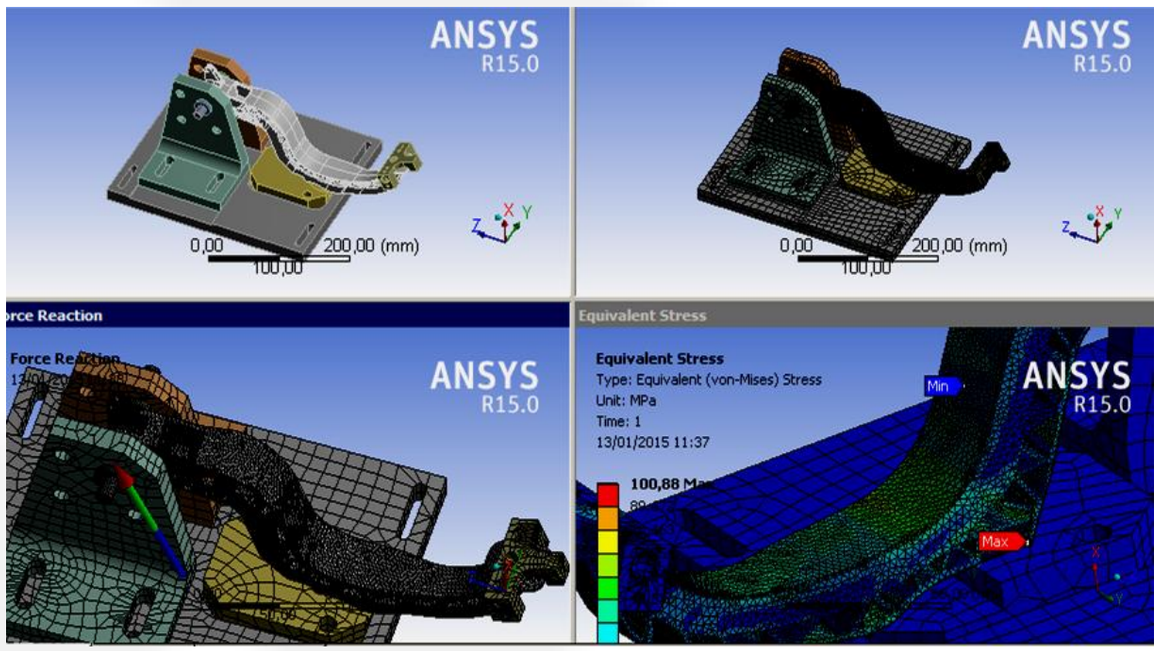
2 cavities mold
3D simulation, 8 elements through thickness
7.000.000 elements



- structural simulations were carried out in Ansys Structural 15.0 according to the boundary conditions used in the experimental testing campaign.

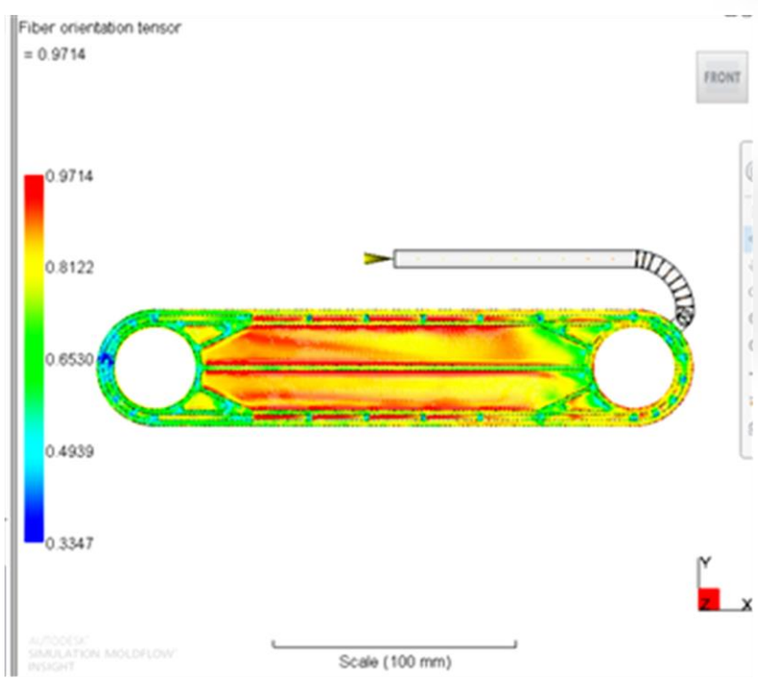


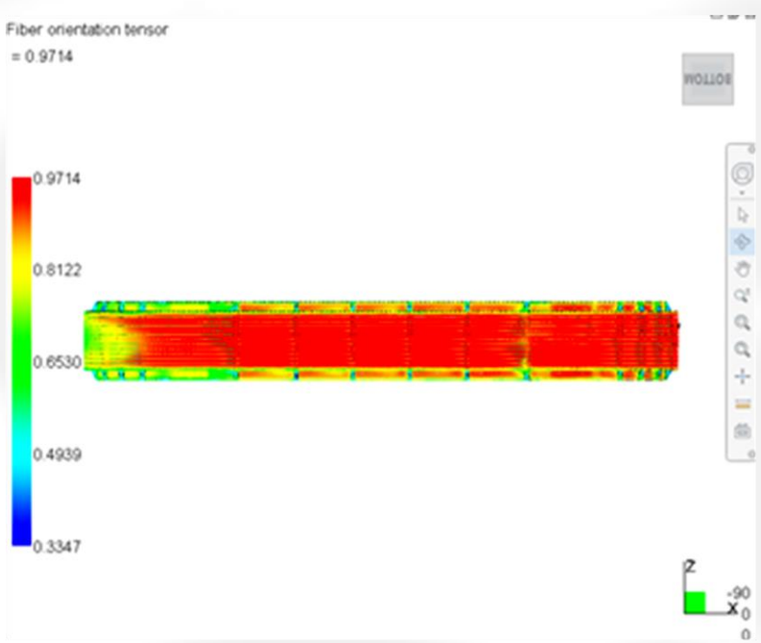


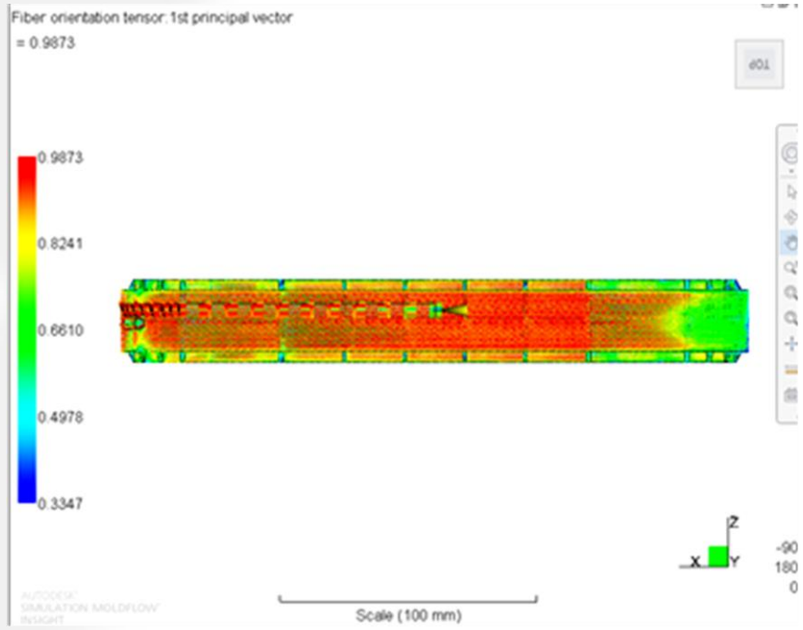


3D simulation, 1-2 elements through thickness
300.000 elements
different models in order to check sensitivity to boundary conditions and mesh.

- Link component:
  - processing parameters used in the injection molding machine were replicated in Autodesk Moldflow® 2015.
  - fiber orientation tensor was considered to be the first order parameter to be taken into account in the coupled analyses.

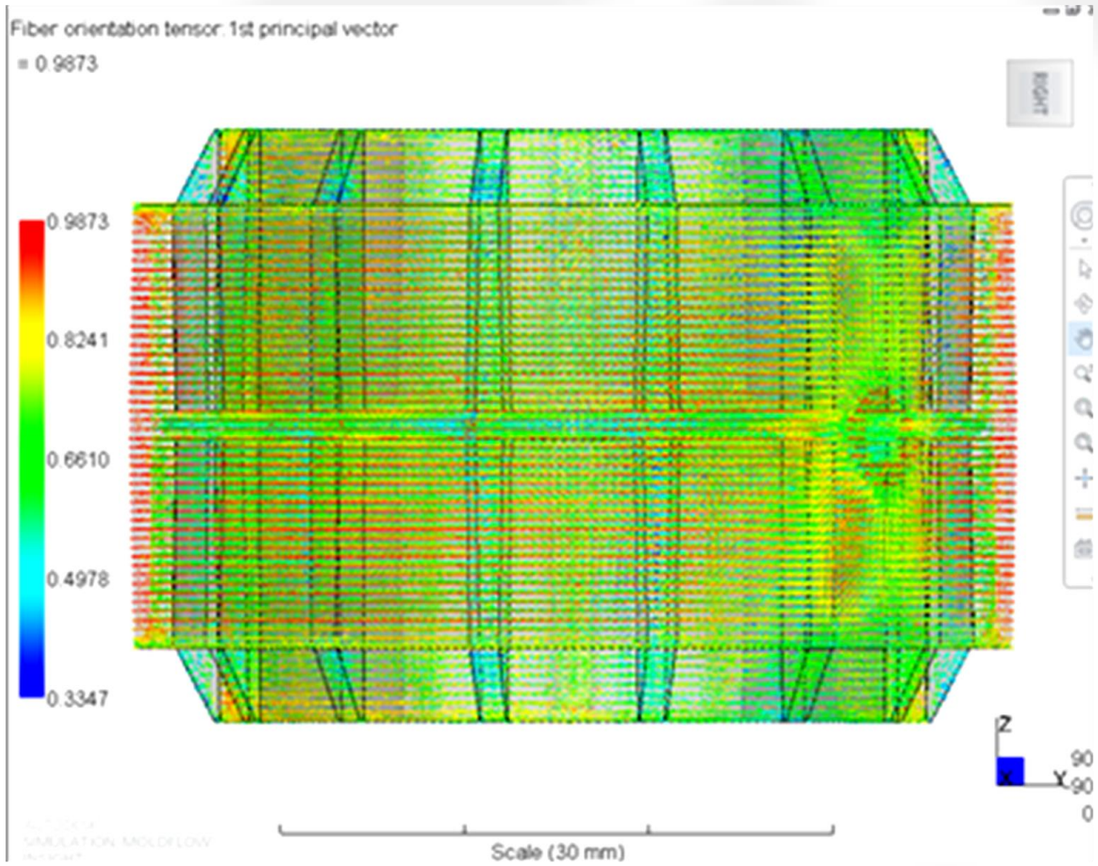


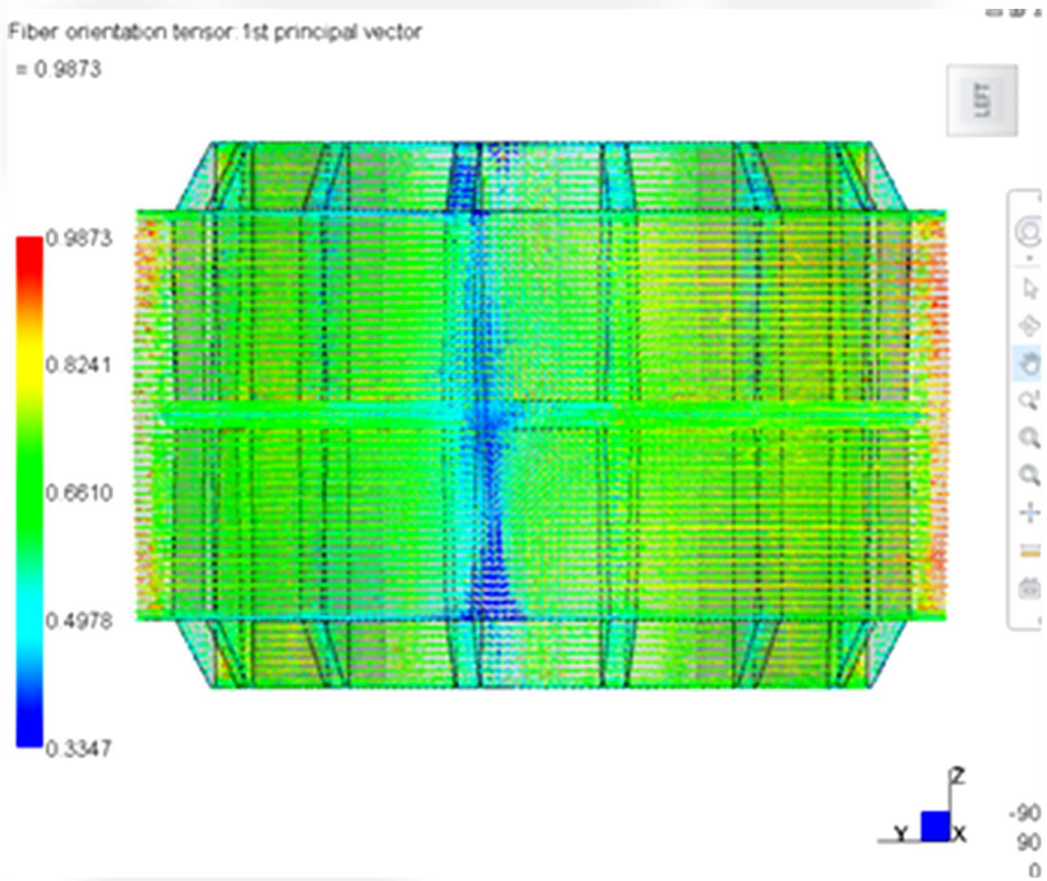




1 cavity mold
3D simulation, 8 elements through thickness
10.000.000 elements

- Link component:
  - a clear weld line is created with the current gate system:

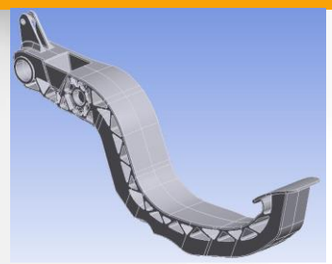


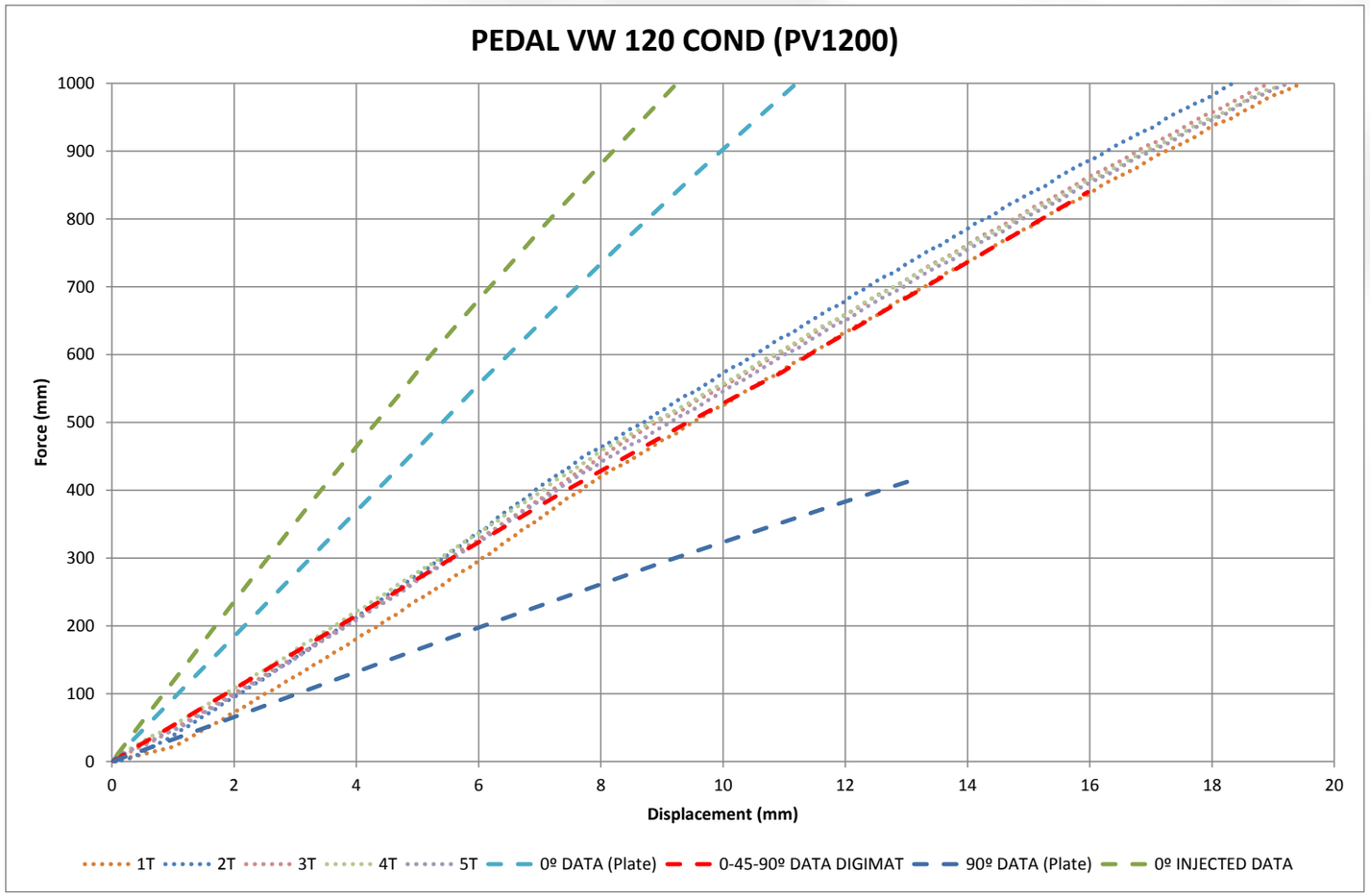


no specific failure model was developed for taking into account weld line effects

Results and conclusions. Components.

- CLUTCH PEDAL. COND.





correlation campaings were focused on COND state, since this was the required condition by the customer.

using the material model RE in Digimat and in addition to the fiber OT from Moldflow, the experimental results are clearly matched!

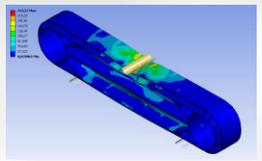
using material data just from one 0º curve (injected or cut from plate), the stiffness is over predicted more than a 42%.

using material data just from one 90º curve (cut from plate), the stiffness is under predicted more than a 43%.

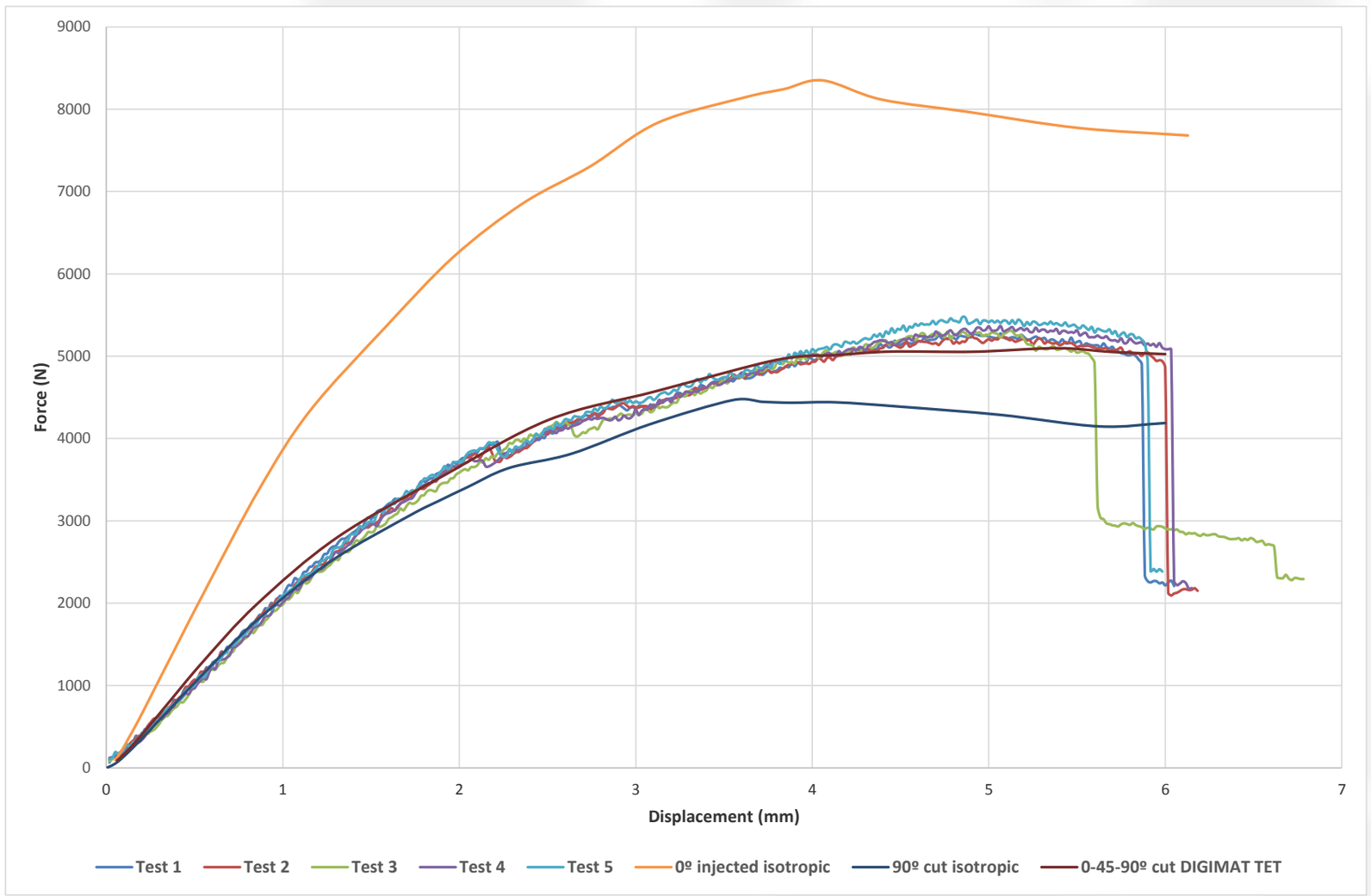
with Digimat, the correlation error is less tan a 5%, and from the safe side of the response.

Results and conclusions. Components.

- LINK. 3 point BENDING. DRY.



correlation campaings were performed both on DRY and COND state.



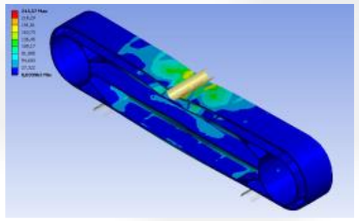
using the material model RE in Digimat and in addition to the fiber OT from Moldflow, the experimental results are clearly matched!

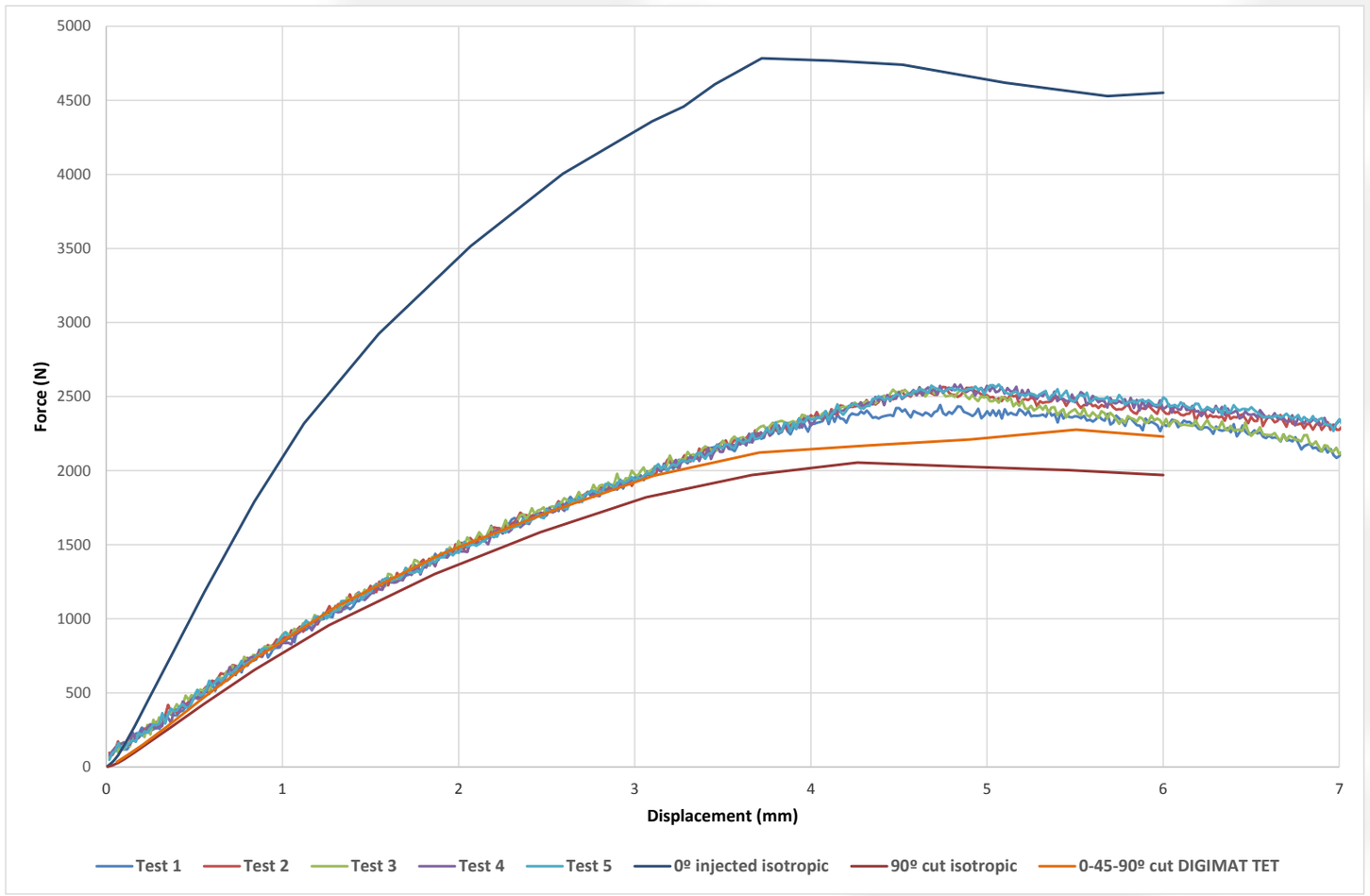
using material data just from one 0º curve (injected), the stiffness is over predicted more than a 37%.

using material data just from one 90º curve (cut from plate), the stiffness is predicted nicely but saturation values are under predicted more than a 20%.

Results and conclusions. Components.

- LINK. 3 point BENDING. COND.





correlation campaings were performed both on DRY and COND state.

using the material model RE in Digimat and in addition to the fiber OT from Moldflow, the experimental results are clearly matched!

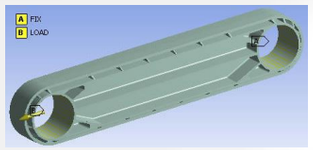
using material data just from one 0º curve (injected), the stiffness is over predicted more than a 48%.

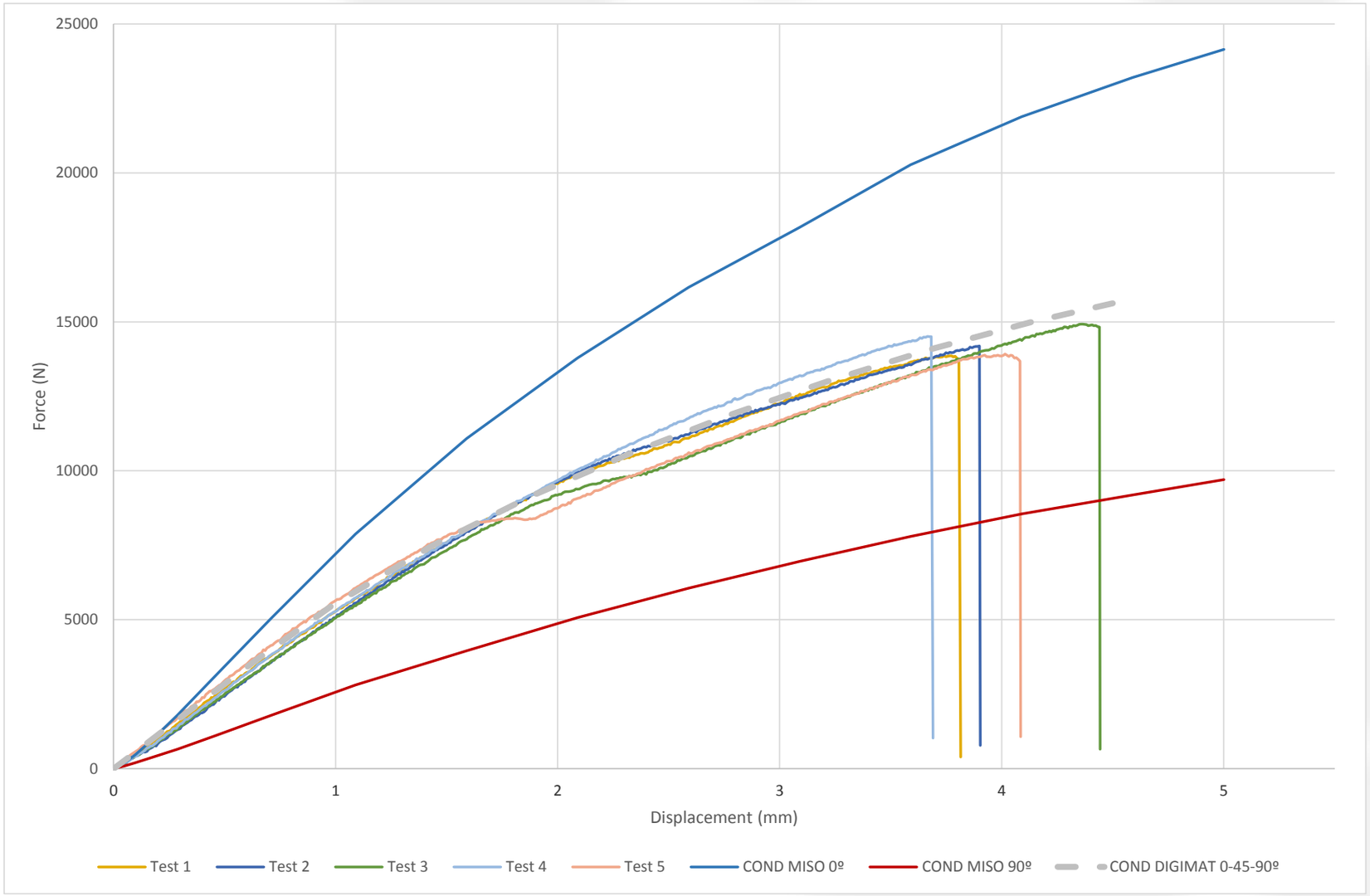
using material data just from one 90º curve (cut from plate), the stiffness is predicted nicely but saturation values are under predicted more than a 20%.

with Digimat, the max. correlation error is around 10%

Results and conclusions. Components.

- LINK. TENSILE. COND.





correlation campaings were focused on COND state, since this was the required condition by the customer.

using the material model RE in Digimat and in addition to the fiber OT from Moldflow, the experimental results are clearly matched!

using material data just from one 0º curve (injected), the stiffness is over predicted more than a 31%.

using material data just from one 90º curve (cut from plate), the stiffness is under predicted more than a 43%.

with Digimat, the correlation error is less tan a 5%.

Conclusions.

- the use of a material model with anisotropic considerations (0, 45, 90º data), and taking into account fiber orientation information, offers the best correlation level to the experimental force-displacement response in both components.

- correlation deviations are less than 5% in terms of stiffness.

- isotropic consideration, using unique curves at 0 or 90º (even at 45º) can not predict properly the experimental response in both components.

  the use of this approach even at initial design stages can lead to considerable simulation error.

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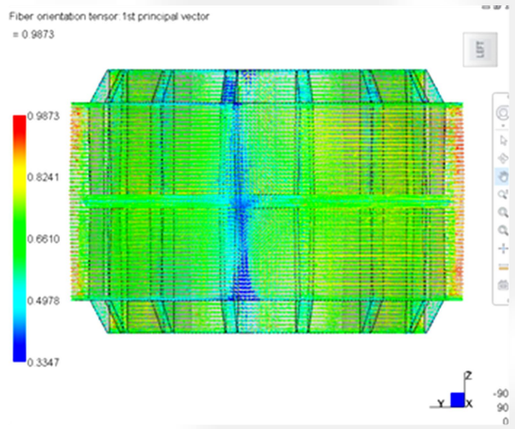
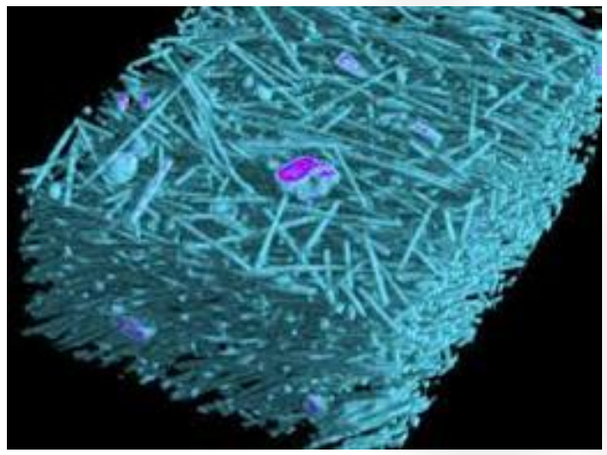
Further developments

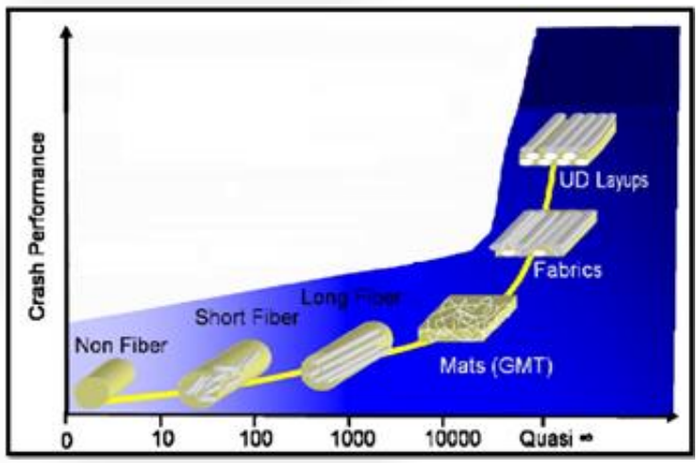
Further developments

- Welding line properties prediction (Link)
  - Failure models



- IMC process simulation
  - Fiber length and orientation before injection process





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Thank you!

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