Celanese
The chemistry inside innovation™

4A TECHNOLOGIETAG

Kunststoffe auf dem Prüfstand - Testen und Simulieren

February, 25th.-26th. 2016

Olaf Herd
Global Automotive Manager

Contents

- Long Fiber reinforced Thermoplastic (LFrT)
- Data Cards
- Simulation for Structural Parts
- Light weight Development
- Celstran Recycling Concept
- Summary and Future

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Semi-Structural Parts Automotive
Light Weight Development as a Global Procedure

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Recyclate

LFT-PP vs CFT PP

„Thin Wall Technology“

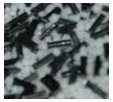
Global Data Cards

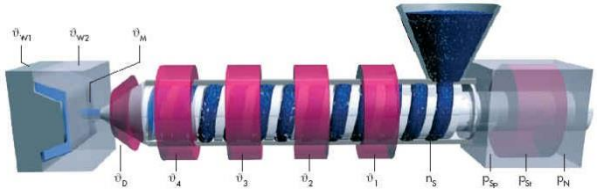
Instrument Panel

Battery Tray

Bumper

Door Module





Tailgate

Electronic Box

Front End

Seat Panel

LFT + LFT Hybrid

Noise Shield

Under Body Panel

Spare Wheel Pan

Chem./ Physical. Foaming

Manufacturing Process – Pultrusion
stands for Quality

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Glass Fiber
Carbon
Aramid
Stainless Steel

Polymer
PP, PA, POM, PBT, PPS etc. + additives

Extruder

Thermoplastic Melt

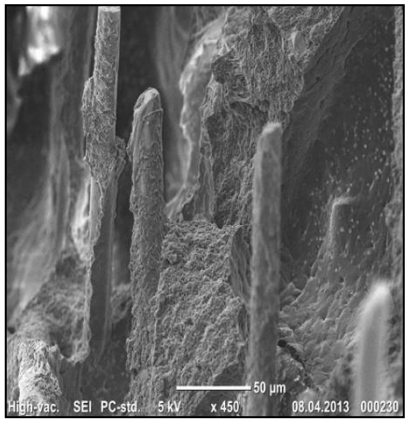
Impregnation Die

Puller

Granulator

LFrT Pellets:
10 mm length for Celstran
25 mm length for Compel

Fully impregnated



Fiber Skeletton

Fiber Length Development
stands for high performance

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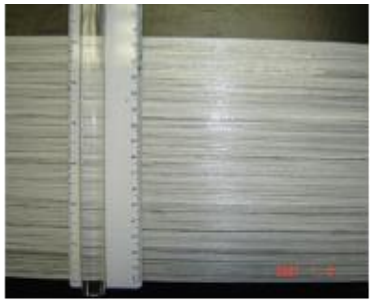
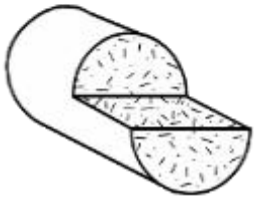
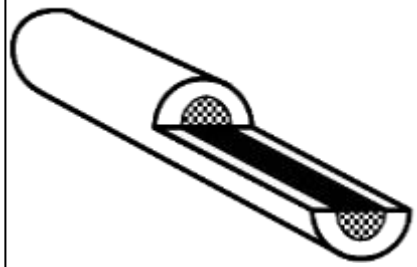
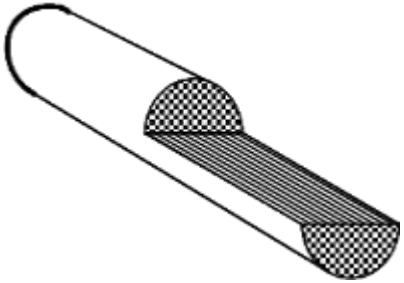
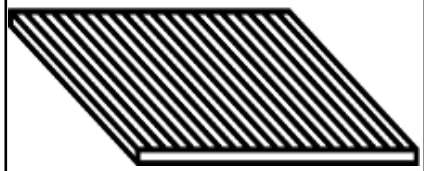
Short Fiber Granule Fiber Length = 0.2 – 0.4 mm	Wire-Coated Or Co-Mingled Fibers	Fully Impregnated Long Fiber Granule Fiber Length =11-25 mm	Fully Impregnated, Continuous Fiber Reinforced Tape (CFR-TP)
			
			
Step 1	Step 2	Step 3	Step 4

…for excellent project development
in cooperation with OEM / Tier 1, 2… as project tracking

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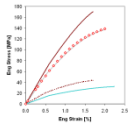
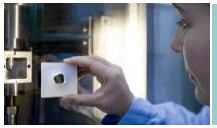
Ideation


Component Design


Material Data Cards


Filling Simulation, Tooling, Production


Testing


Component Validation

Personal Vehicles & Commercial Vehicles

OEM Specification

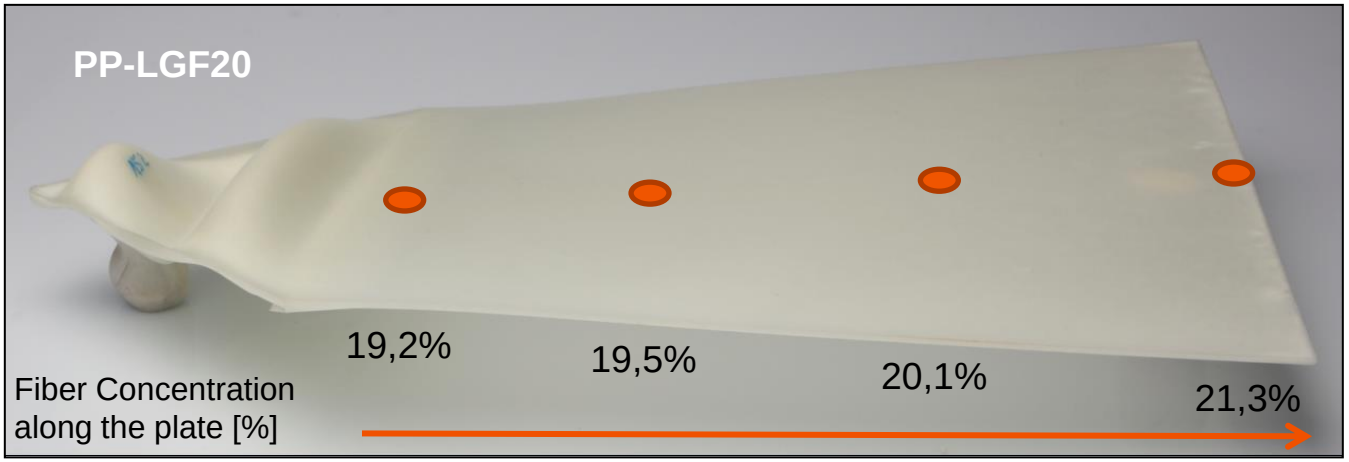
Specification – as requirements for a global process

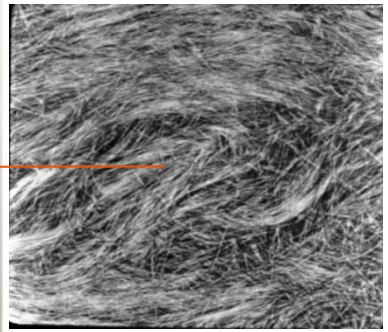
Valuable cooperation – right from the start.

- Long Fiber reinforced Thermoplastic (LFrT)
- Data Cards
- Simulation for Structural Parts
- Light weight Development
- Celstran Recycling Concept
- Summary and Future

Moldflow Simulation

Filling study on 2.5 mm plaque – PP-LGF20 vs PP-LGF50



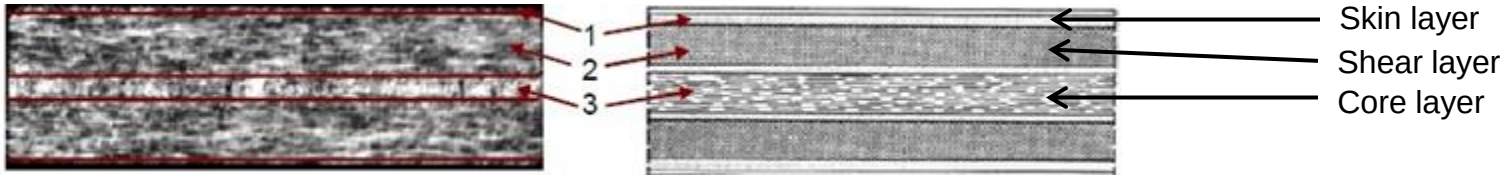


Celstran PP GF20

Celstran PP GF50

Different flow fronts depending on fiber content.
Filling behaviour (flow front) can not be simulated correctly.

CT Analyzes: Fiber Length Distribution and Orientation over Thickness



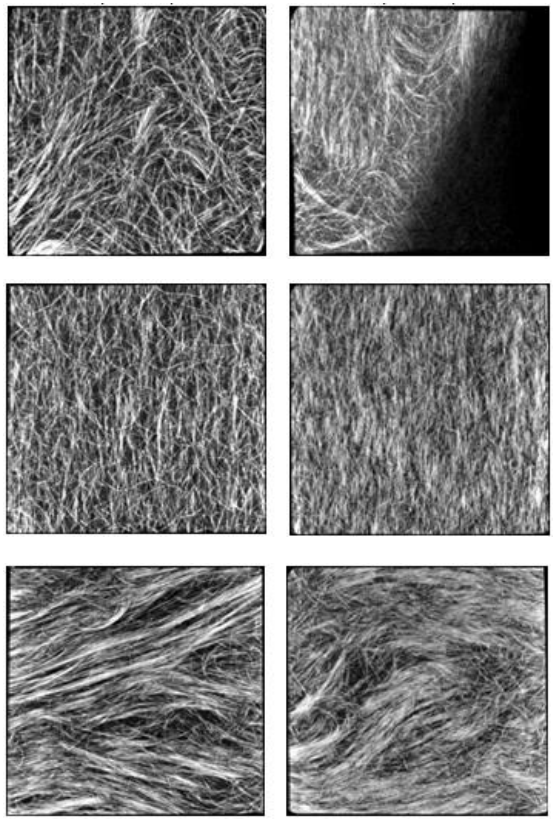
cross section

schematic layer structure

Celstran PP GF20 blend

Celstran PP GF50

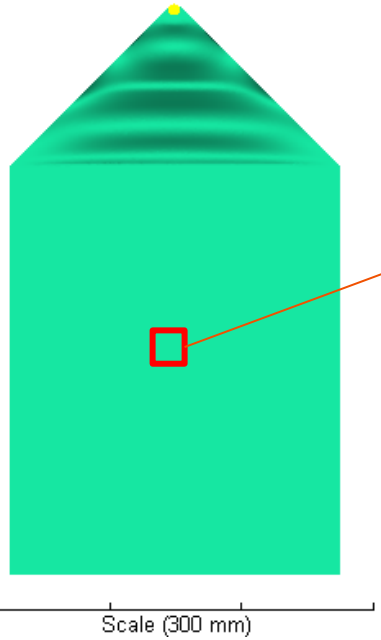
Flow direction

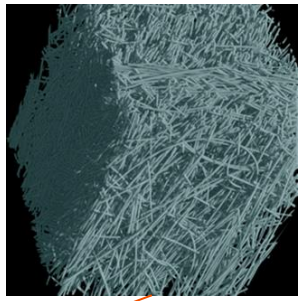


Skin layer (1)

Shear layer (2)

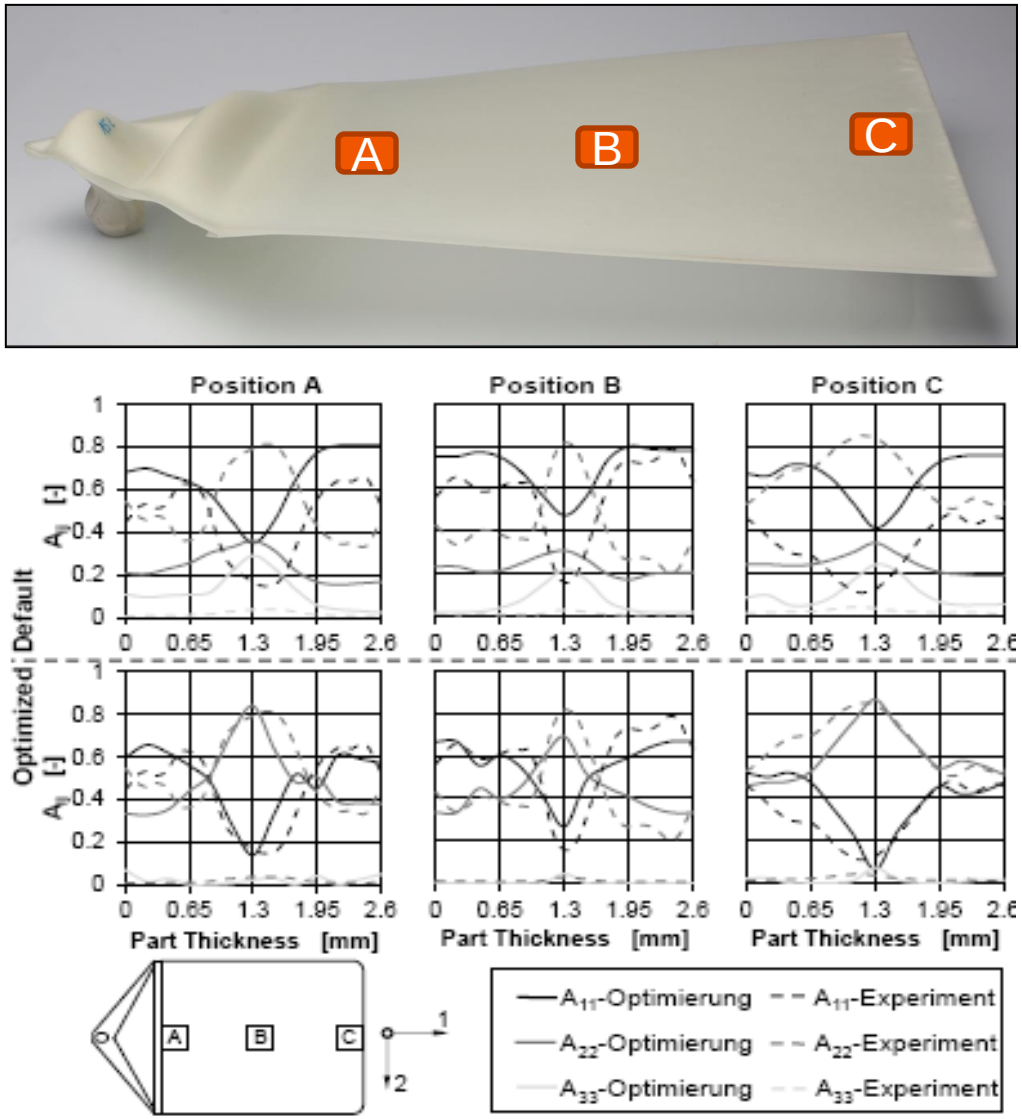
Core layer (3)





ARD-RSC Model

Data base for Molfflow on 2.5 mm plaque – PP-LGF20 [1]



3-point bending test for creating LS Dyna
on 2.5 mm plaque – PP-LGF30 – 3 directions

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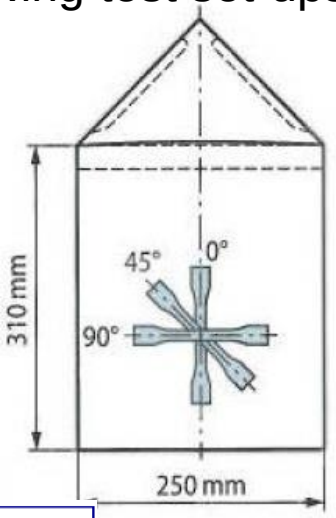
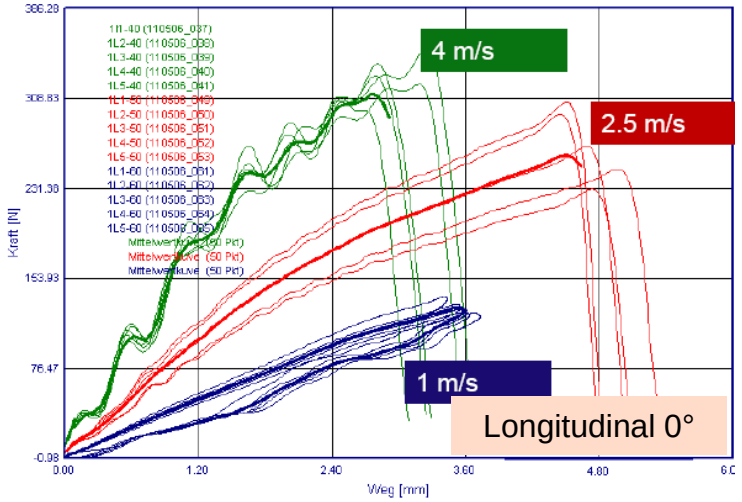
3-point bending test

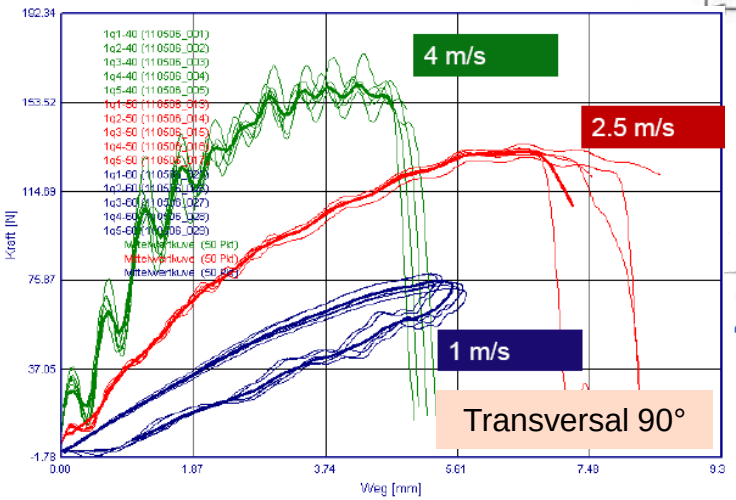
- Analytical estimation of the range of strain rates leads to the following test set-ups

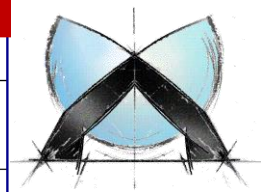
Distance between Supports l_w [mm]	Velocity of Pendulum v [m/s]	Strain Rate epsilon_pkt [1/s]
50	1	0 - 10
40	2.5	10 - 20
30	4	60 - 100



- The strain rate is not of constant value (see given range).
- Each test configuration is repeated three times.







4a impetus

- Long Fiber reinforced Thermoplastic (LFrT)
- Data Cards
- Simulation for Structural Parts
- Light weight Development
- Celstran Recycling Concept
- Summary and Future

Structural parts in PP-LGF

Typical Requirements:

- **high stiffness**
- **energy absorbance**
- **part integration**

→ material, design

- **low warpage to match precision needs for assembly**

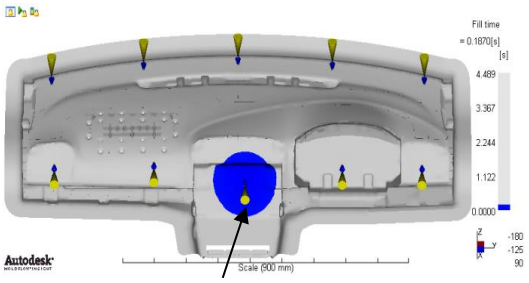
→ design, tooling, processing

- **weight reduction through thin-walled design**
- **Foaming Process**

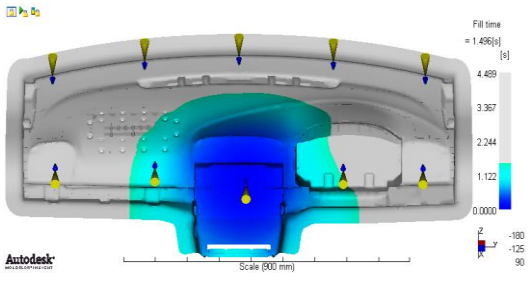
→ design, processing

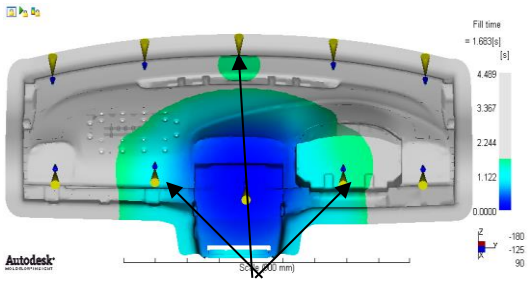
Celstran ® is a high quality LFT. Typically 20 or 30 % GF content used for IPs

IP Filling Study
10 Gates timed with Cascade Principle

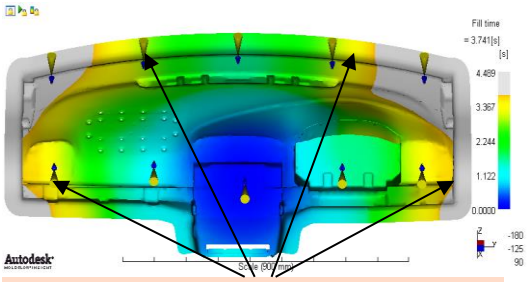


Gate 6 open

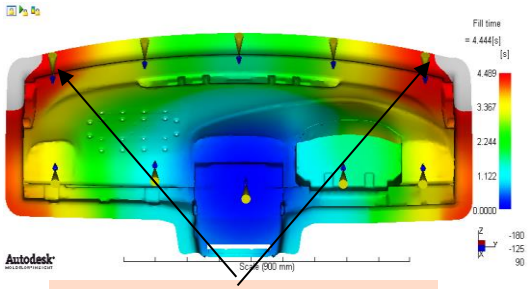




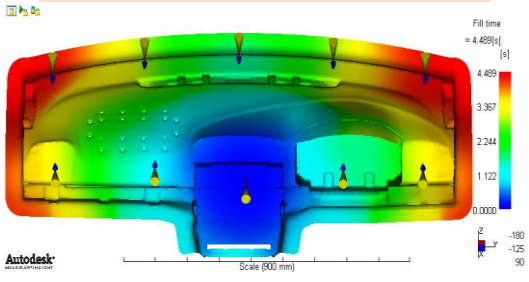
Gate 4, 5 and 8 open at 1.62 s



Gate 2, 3 and 7, 10: open at 3.6 s

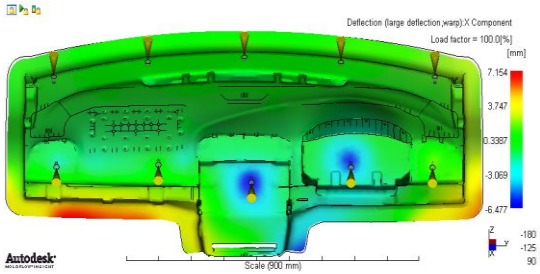


Gate 1,9 : open at 4.4 s

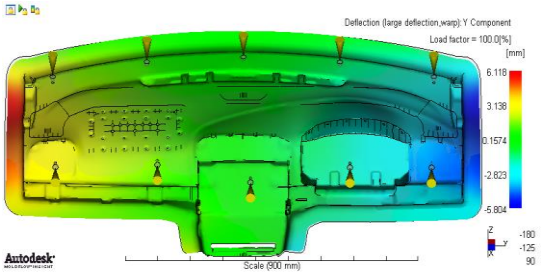


- Cascade gating commonly used for large parts.
- Practical filling study corresponds to the Moldflow study.

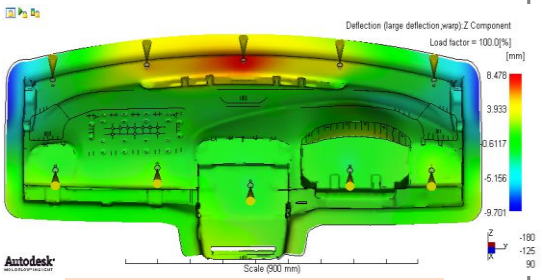
IP Shrinkage and Warpage



Deflection in X direction

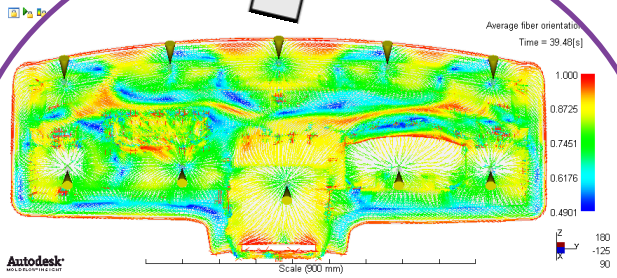


Deflection in Y direction



Deflection in Z direction

Finished IP: low warpage / homogenous surface



Average fiber orientation in flow direction

Fiber orientation mainly determines the warpage behaviour of the part.

Light weight engineering

Experience in Moldflow

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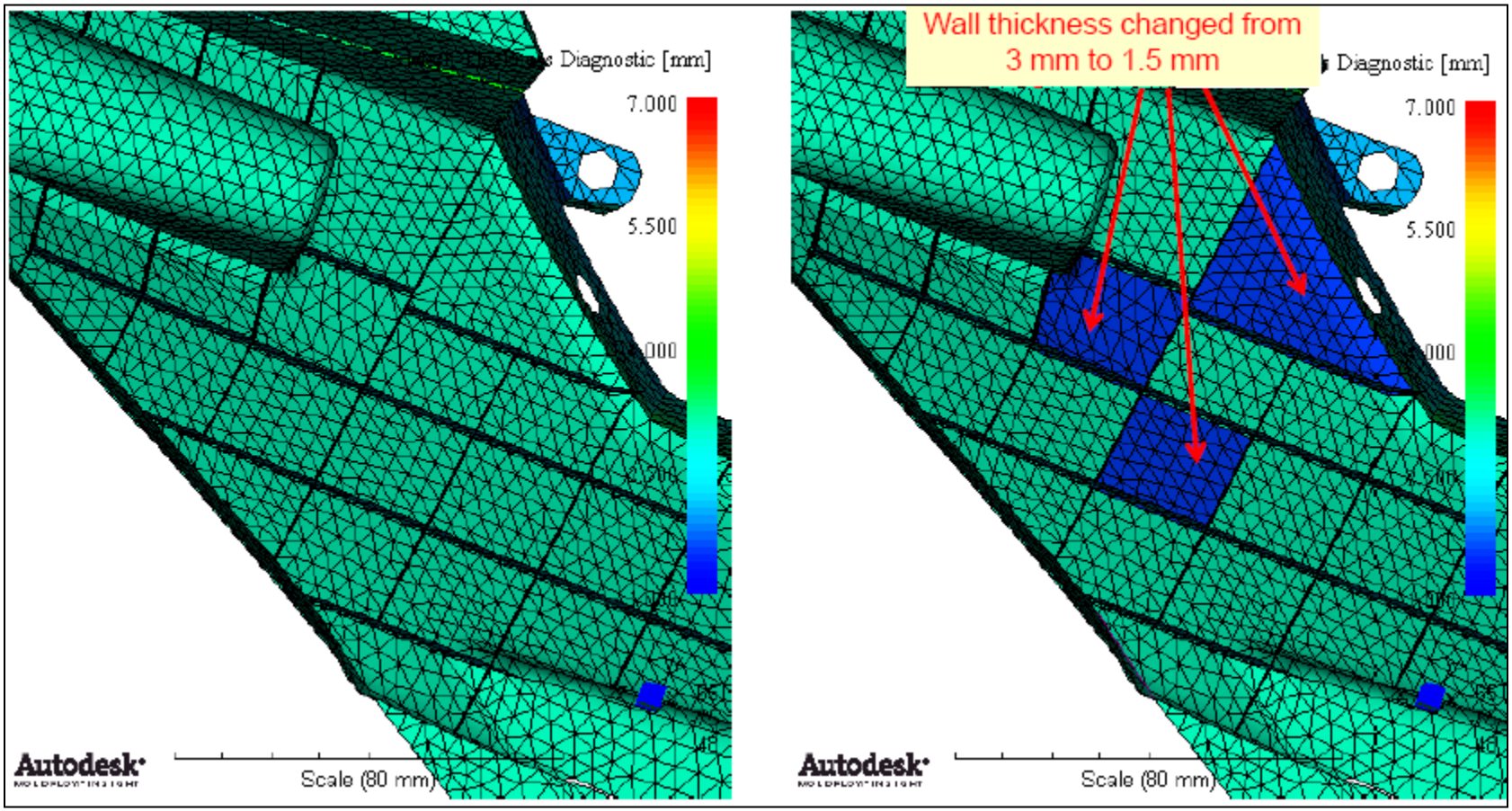
Thin wall design to influence the glass fiber matrix flow



Light weight engineering

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Celanese

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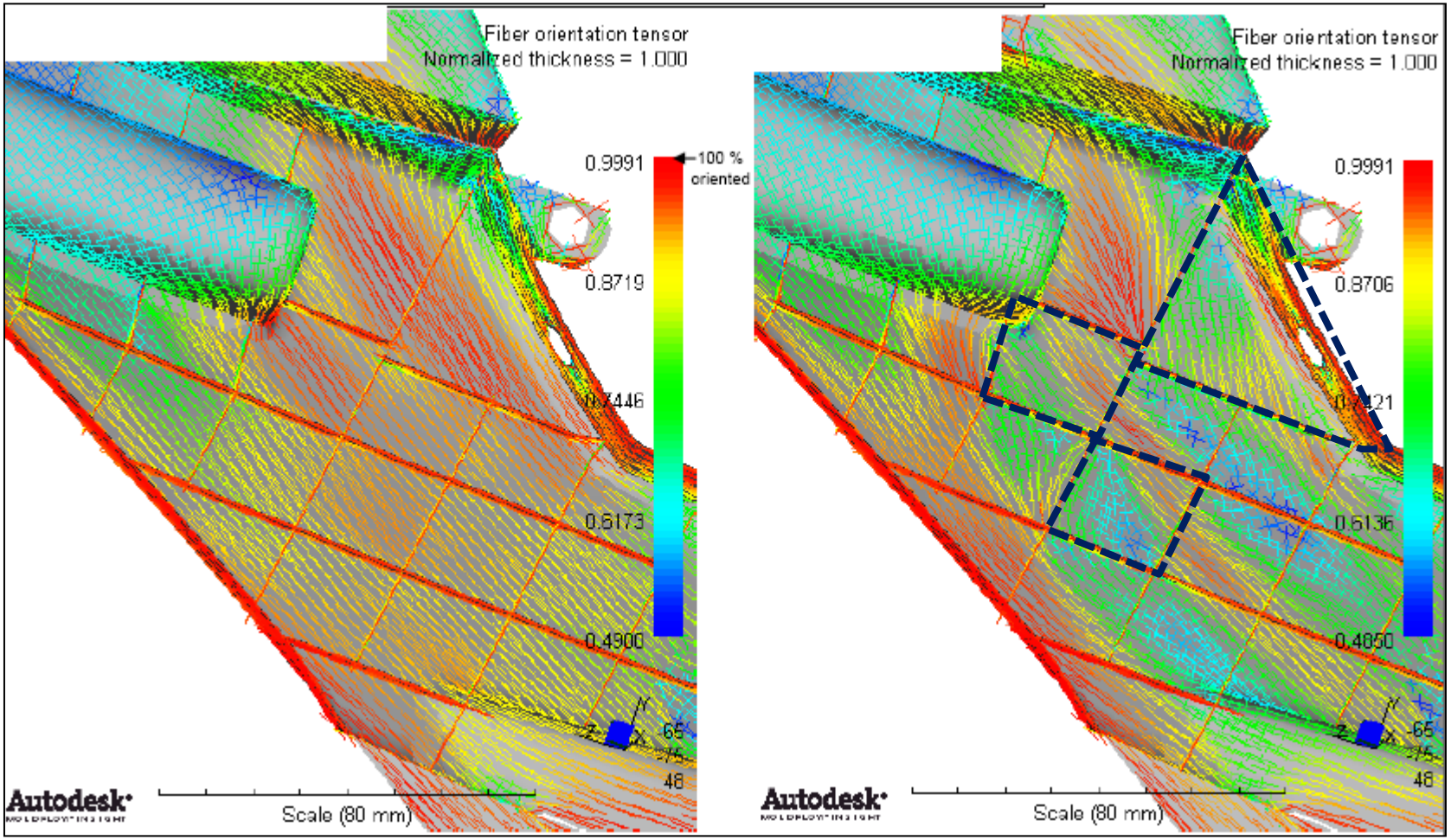

- Long Fiber reinforced Thermoplastic (LFrT)
- Data Cards
- Simulation for Structural Parts
- **Light weight Development**
  - Physical vs chemical foaming
- Celstran Recycling Concept
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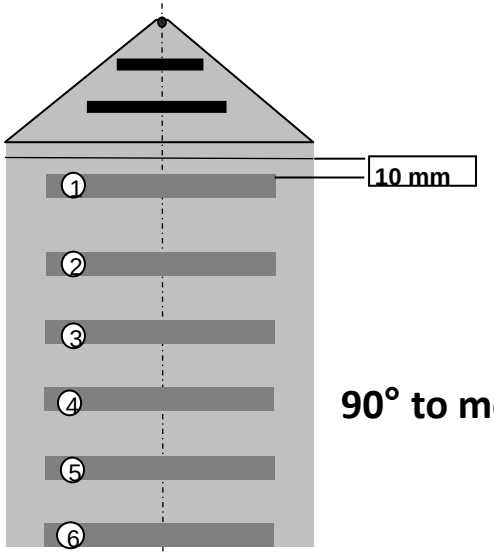
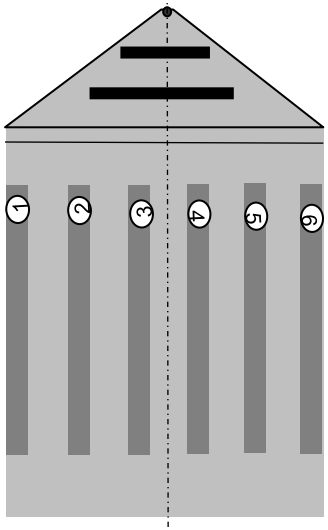
Test Plan according to a OEM spec

MuCell vs chem Foaming, plaque 2,5 mm wall thickness

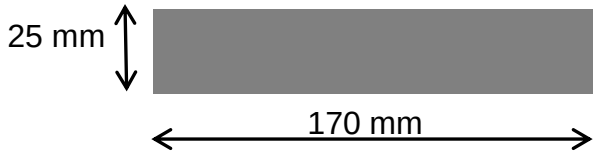


90° to melt flow / transversal

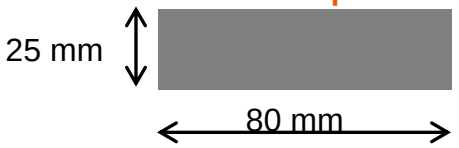


0° to melt flow / longitudinal

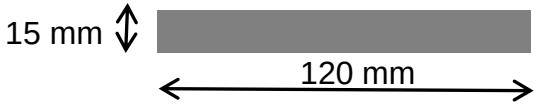
Tensile Specimen



Flexural Specimen



Impact Strength



Test program

- Tensile test
- Flexural test
- Impact strength
- Fiber length
- Cell dimension and distribution
- Adhesion between Fiber and matrix
- Odor and emission

Material Performance
Solid vs MuCell vs chem Foaming: 2,5 mm wall thickness

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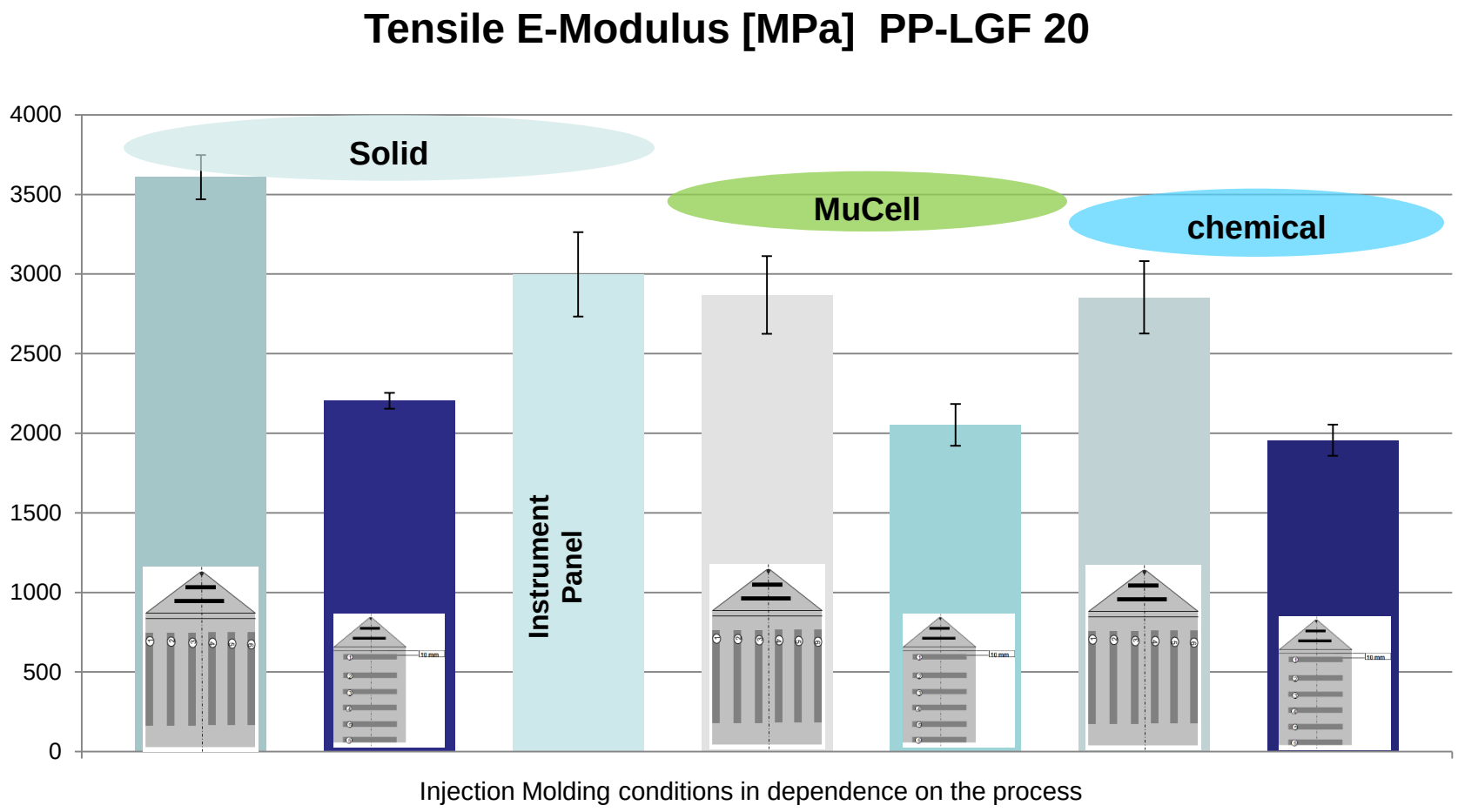

Injection Molding conditions in dependence on the process

Foam-Process and its Cell distribution

all over the wall thickness [2,5 mm]

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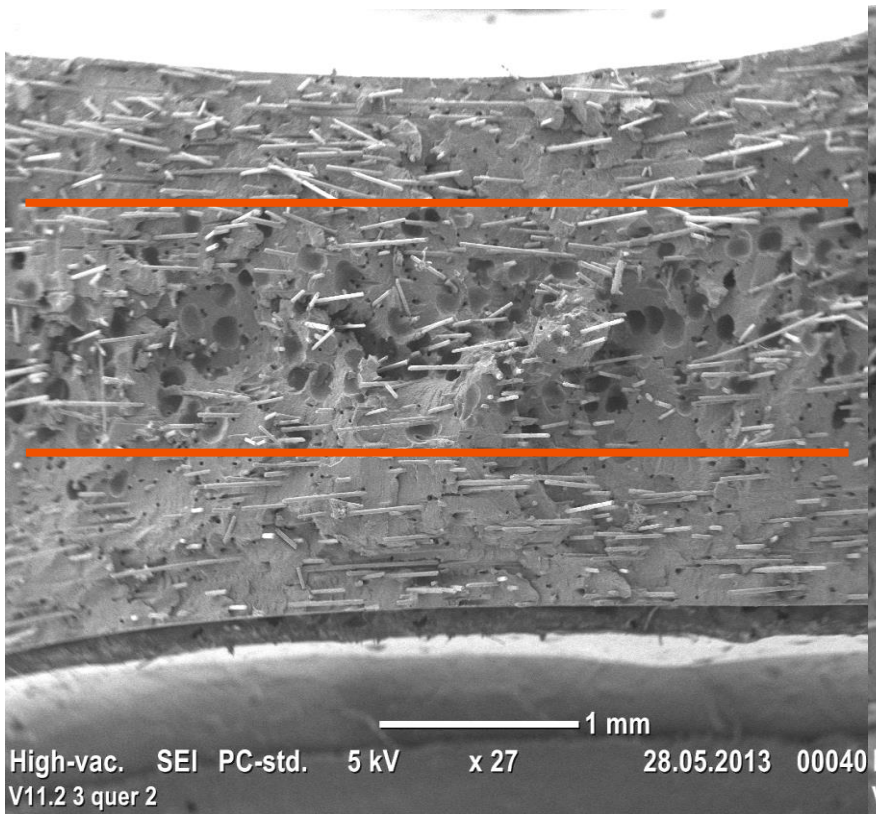

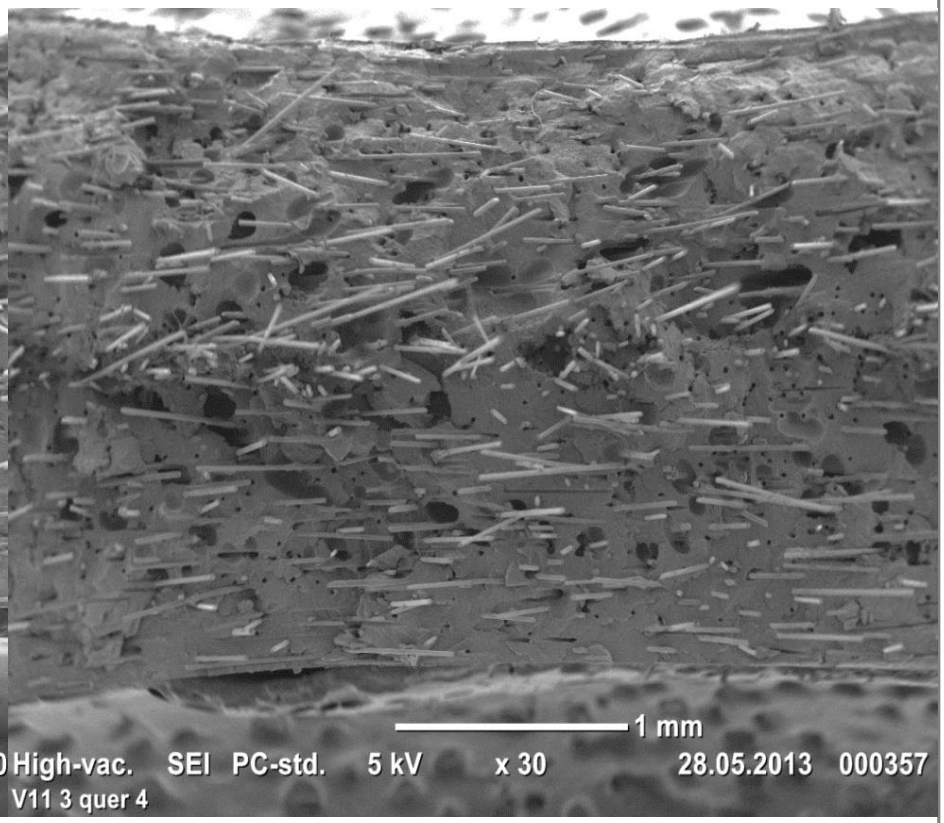

Chemical foamed

Physical foamed

MuCell vs chem Foaming
Comparison of Celstran PP-GF20

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Mechanical Properties 2,5 mm Plate*						
		Tensile Test 23°C	Flexural Test 23°C	Impact Strength 23°C	Impact Strength -35°C	Weight Reduction
2,5 mm Plate	solid	100%	100%	100%	100%	100%
	MuCell	82%	93%	93%	80%	-11,60%
	chemical	78%	87%	93%	74%	-12,40%

*** The Feasibility Study was done on MuCell Aggregate for doing a direct Comparison each other.**

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Shredder and Regrind

Celstran PP-GF20 Blend – regrind and Tape vs Organo Sheet

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HOFFMANN + VOSS
TECHNISCHE KUNSTSTOFFE

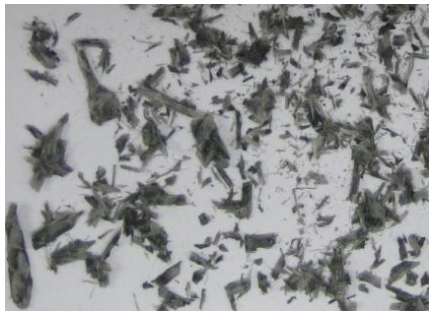
Molded IP

Regrind

Mixture of PP-LGF + PP+ Regrind

UD Tape-Recyclate

Organo Sheet-Recyclate



Test Results out of Cockpit Process

PP-LGF 20 with 10 and 20 weight% regrind

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Test procedure All RT		Required**	IP Wall thickness < 2,2 mm	Virgin + 10% R	Virgin + 20% R
Density	**g/cm³**	**1 ± 0,02**	**1,02**	**1,02**	**1,02**
Ash Content	**%**	**20 ± 2**	**21**	**20**	**20**
Tensile test E-Modulus	**MPa**	**2.300**	**3.500**	**3240**	**2870**
Flexural Test Flexural Strength	**MPa**	**40**	**65**	**72**	**65**
Impact Strength	**kJ/m²**	**20**	**60**	**52**	**46**
Tensile Strength	**MPa**	**40**	**50**	**52**	**46**
Elongation at break	**%**	**2,0**	**3**	**2,9**	**2,9**
VDA 277	**µgC/g**		**35**	**< 30***	**<30***

*Optimized IM parameters→ low melt temperature….
** vs OEM spec

Recycling Concept

PP-LGF in comparison with UD Tape and Organo Sheet recyclate

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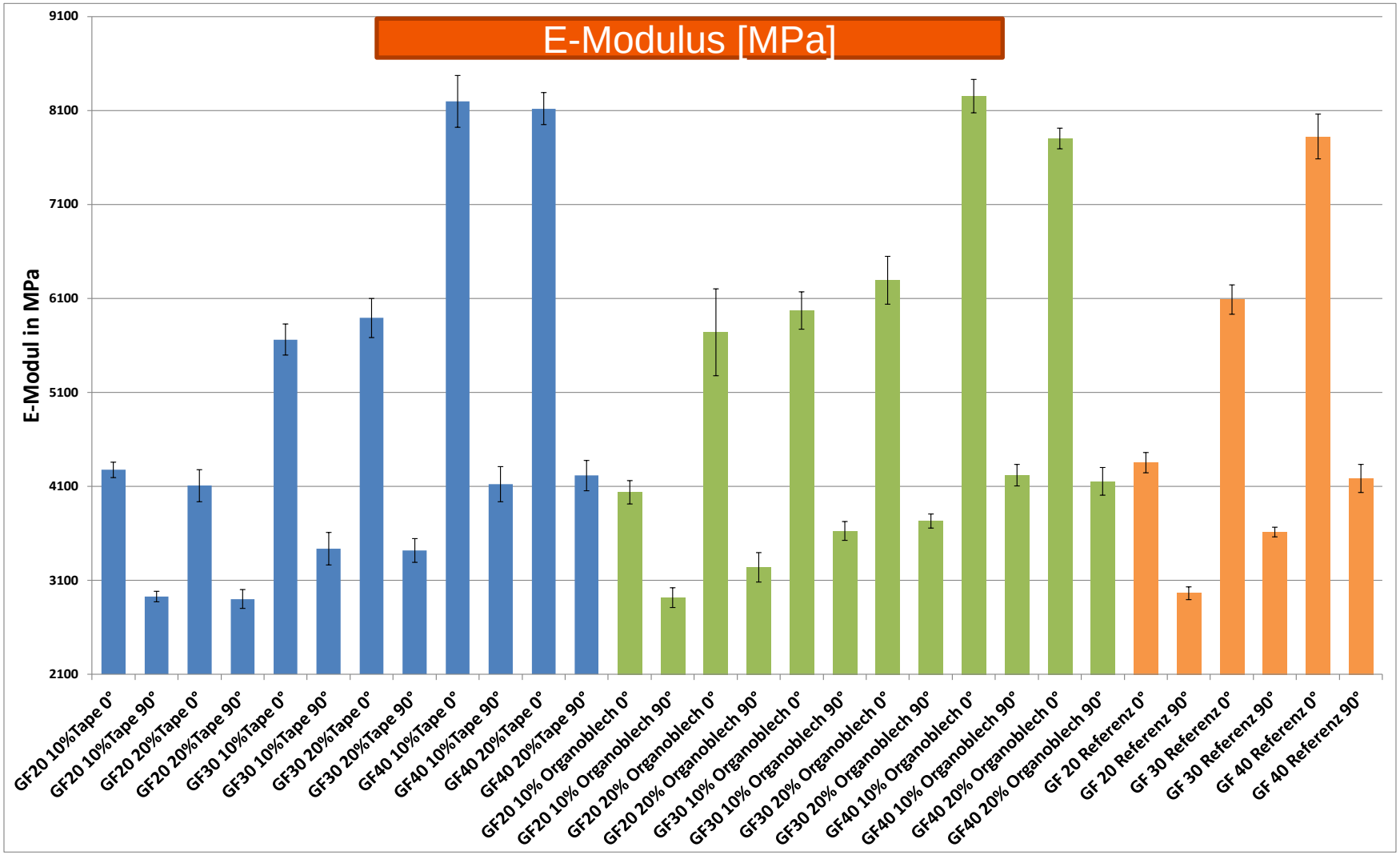

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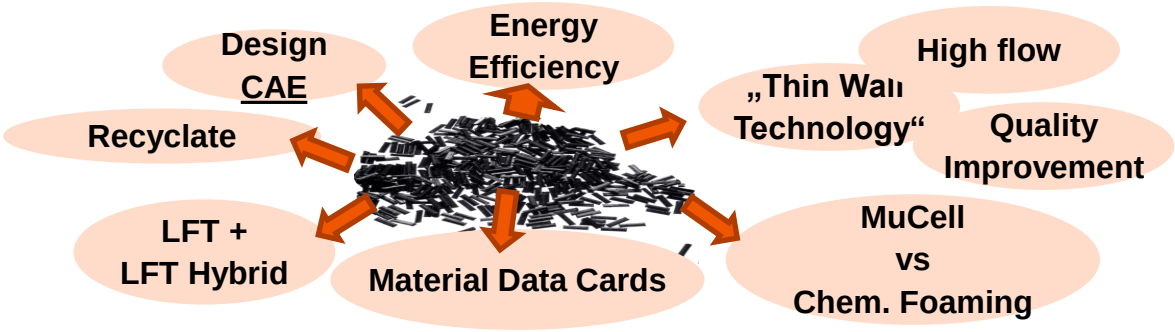
Summary and Future

- Long Fiber reinforced Thermoplastic will be used for structural parts including crash absorption
- Data Cards have to be offered as a package: Campus, Mat 24 and ARD-RSC Model, …..
- Simulation for Structural Parts have to be done as efficiency as to work out a short development phase and reducing those costs
- Light weight Development necessarily for reducing the CO_2 Emission…
- Celstran Recycling Concept – more important because of the „Old Vehicles Regulations“
- Optimization Process for creating data cards, which offer a more realistic part development including dynamic crash tests etc…
- Due to the thin wall development and foaming procedure, there are required more and more data, which currently are not available



Quality Window
to be defined with a variable support width

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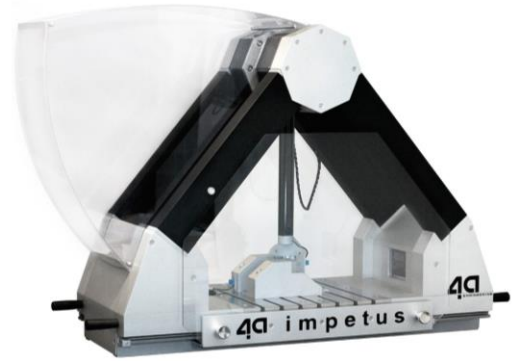
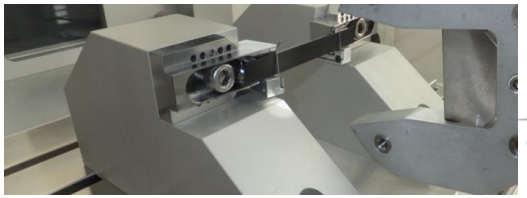
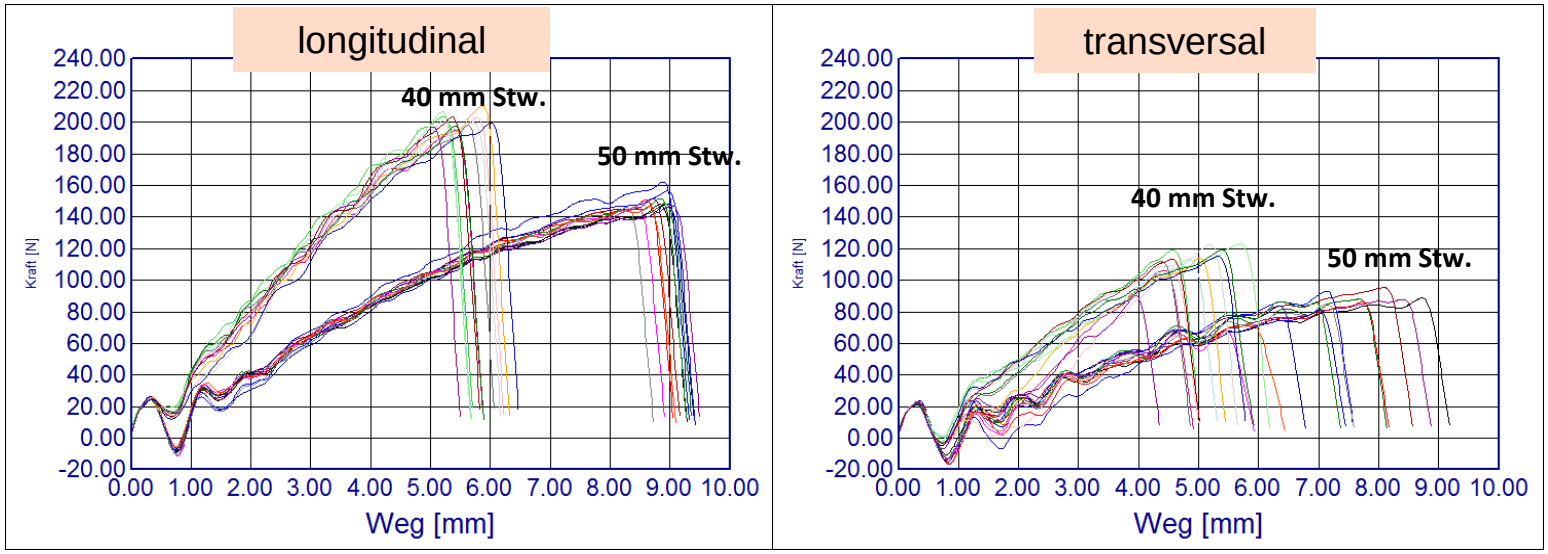


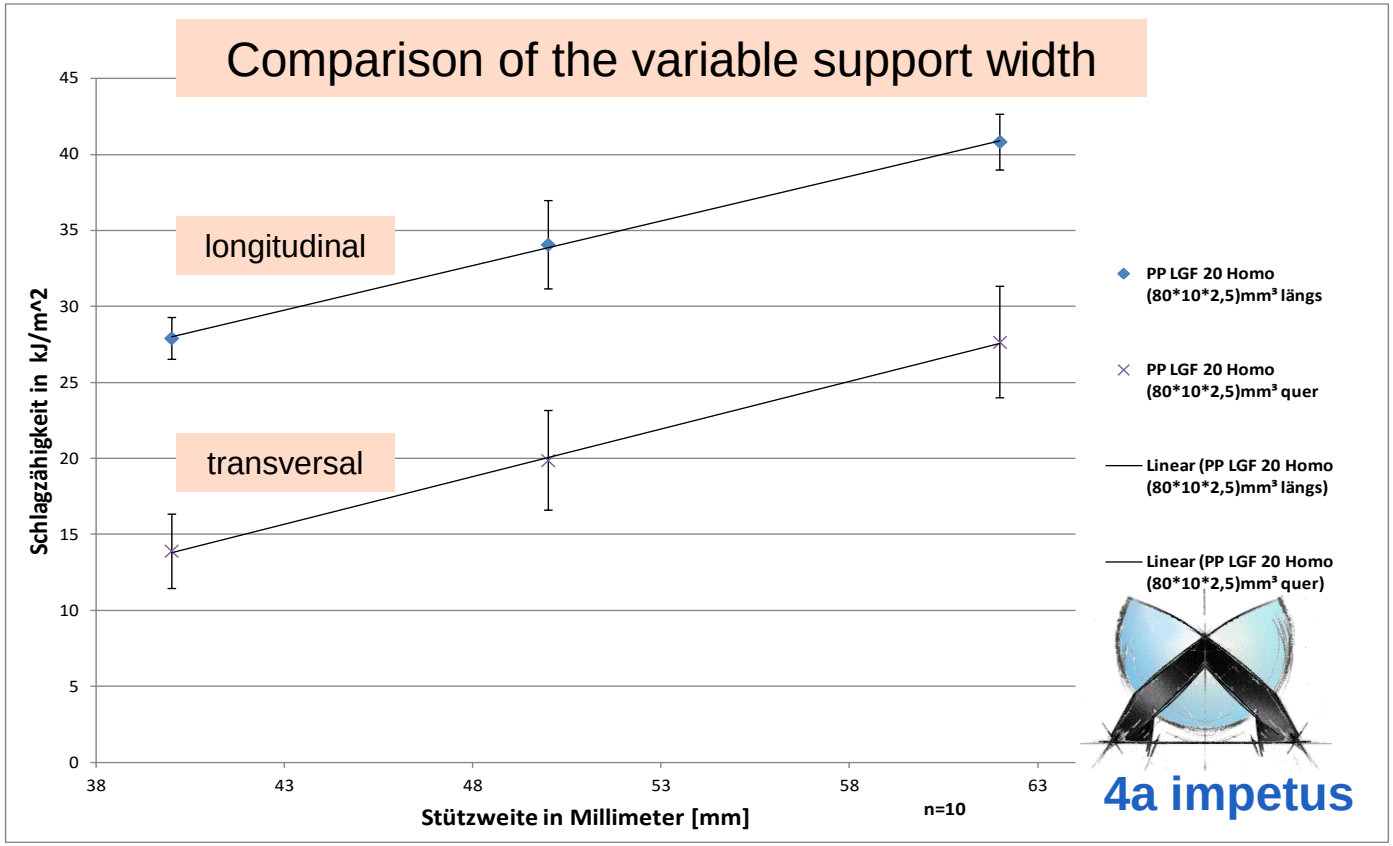


4a impetus

- Transversal test specimen create a higher deviation
- Longitudinal test specimen can take over
  a higher energy absorption
- With smaller support width (increasing strain rate),
  the power consumption is increasing
  and the deformation is shrinking



Impact Test as ISO 179-1



- Linear link between Impact strength and support width
- in dependence on the variable support width the transversal test specimen show a lower Impact strength

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Vielen Dank für Ihre Aufmerksamkeit
Fragen?

Kunststoffe auf dem Prüfstand - Testen und Simulieren

4Q TECHNOLOGIETAG

legend

[1] FIBER ORIENTATION PREDICTION OF LONG FIBER-REINFORCED THERMOPLASTICS: OPTIMIZATION OF MODEL PARAMETERS

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