

From Injection Molding to Structural Analysis

An End-to-End Solution

Moldex3D-Digimat-MSC Software

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Moldex3D
MOLDING INNOVATION

eXstream
ENGINEERING
MSC Software Company

INDUTRY CHALLENGES



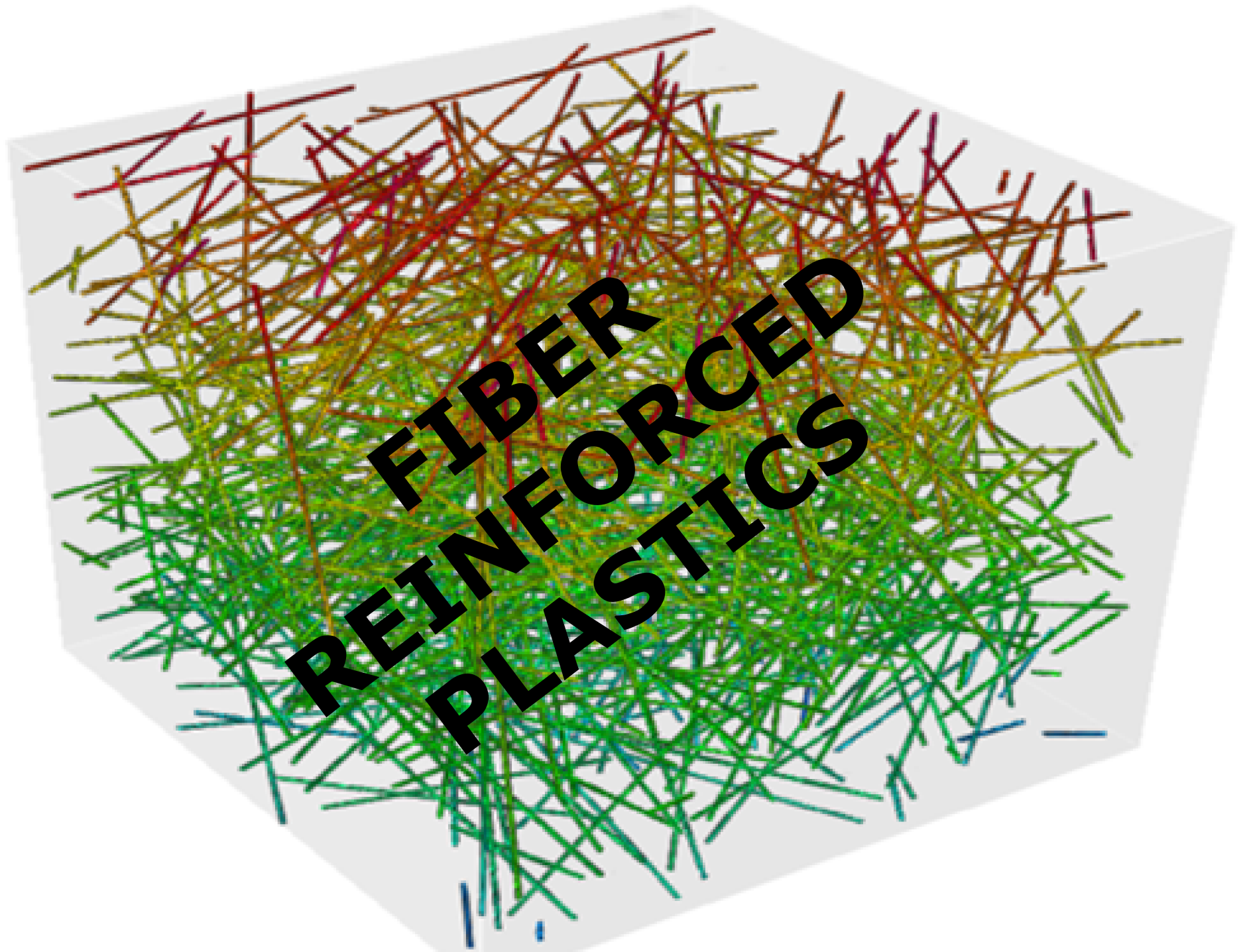
High-Performing Products



Eco-Friendly Products



Cost-Effective Products



WHAT ARE THE CHALLENGES IN MODELLING RP?

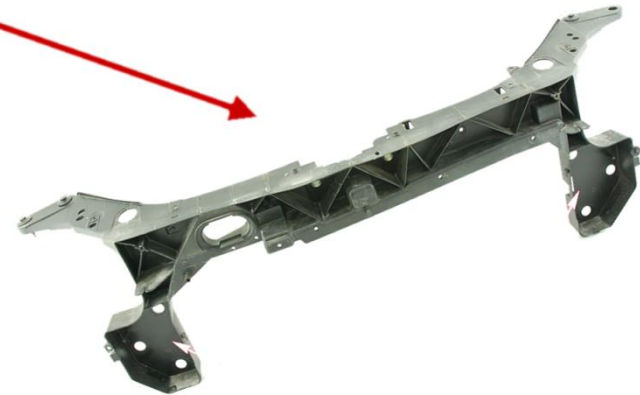
**Nonlinear
Anisotropic
Strain Rate
Dependent
Process Dependent**



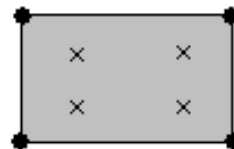
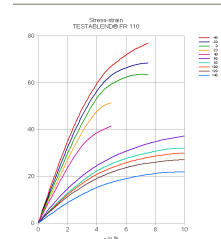
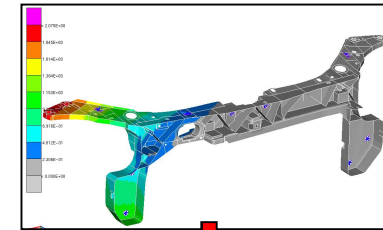
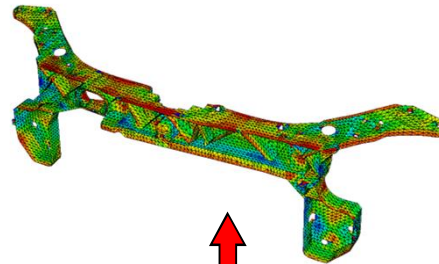
Let's take a simple example ...



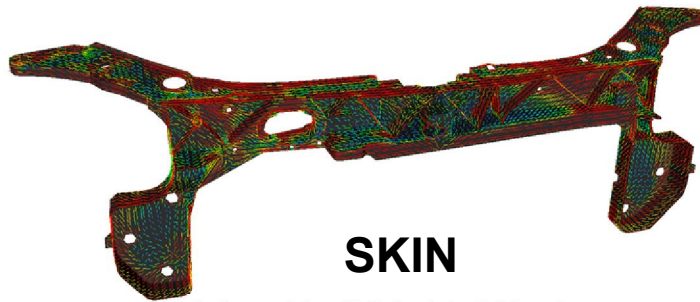
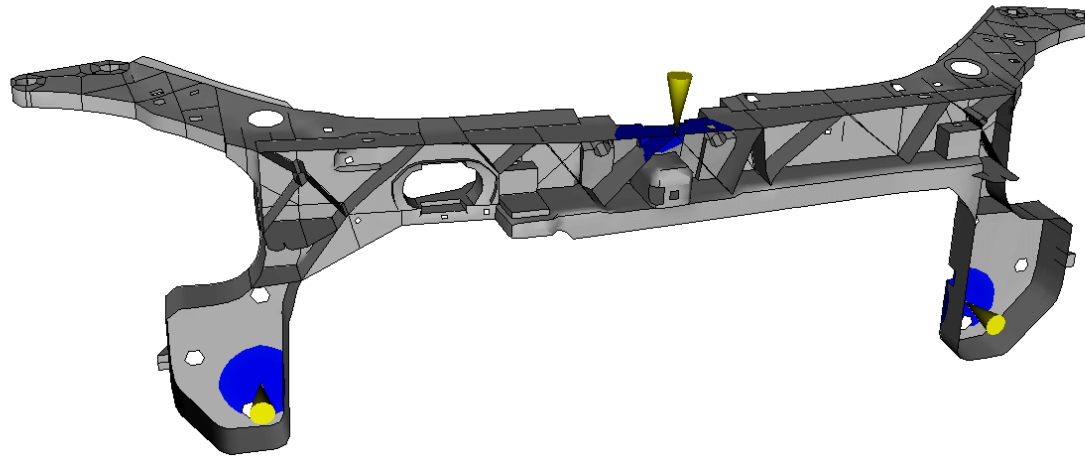
- “ Front-end from Renault
- “ PP-LGF
- “ Injection molded part



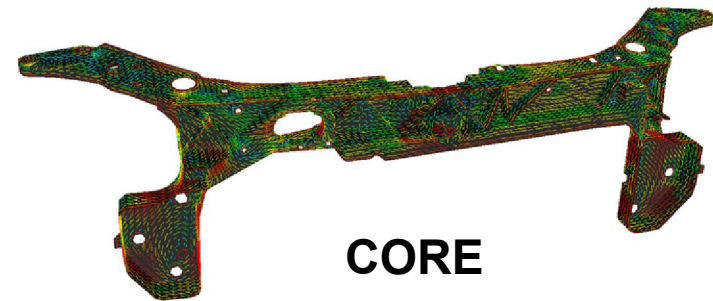
With Classical FE Modeling tools...



Reality is different ...

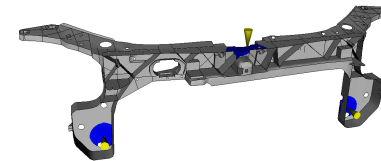
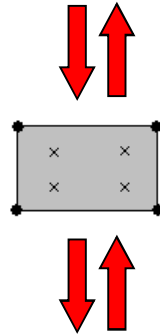
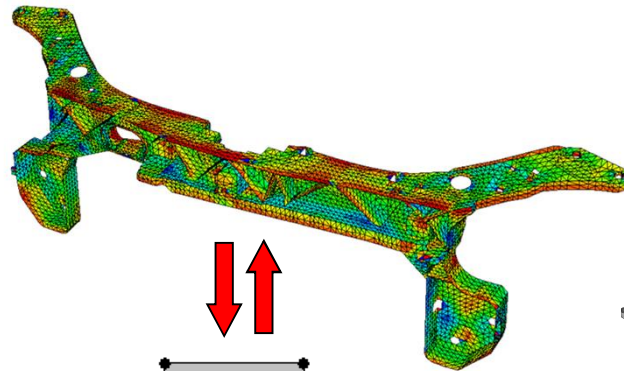


SKIN

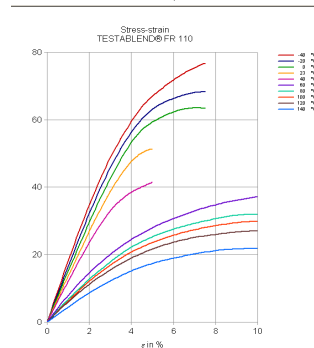


CORE

Manufacturing impacts Structural Performance



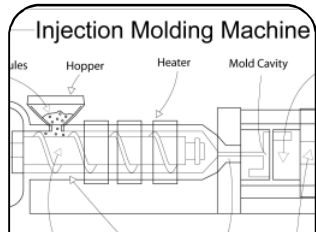
Moldex3D



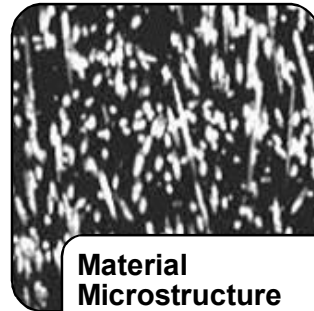
Replace the usual basic material models by **Digmat material models!**
 Accounting for

- “ Local microstructure (AR, θ , w.f.)
- “ Nonlinearity
- “ Strain-rate dependency
- “ Thermo-dependency

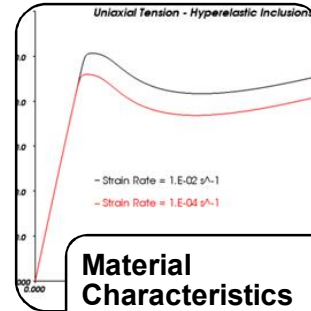
From Simulation to Final Structural Performance



Material Processing
"Injection
"Compression



Material Microstructure
" Short Fibers
" Long Fibers
" MuCell



Material Characteristics
" Mechanical
" Thermal
" Electric, ...



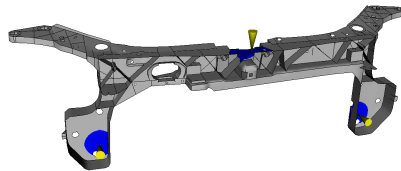
Component/System Performance
" Stiffness, Strength
" Fatigue
" Creep, $\dot{\epsilon}$

Molding

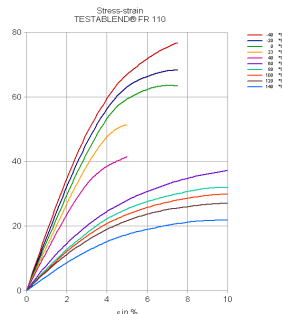
Multi-scale Modeling

Structural FEA

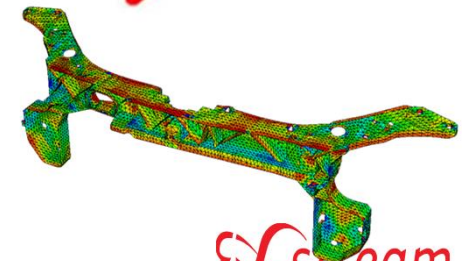
Moldex3D®



Digimat

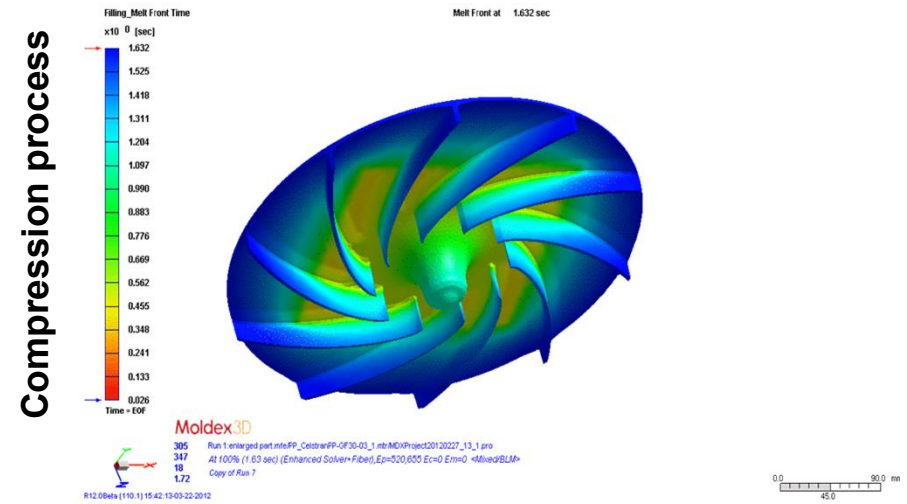
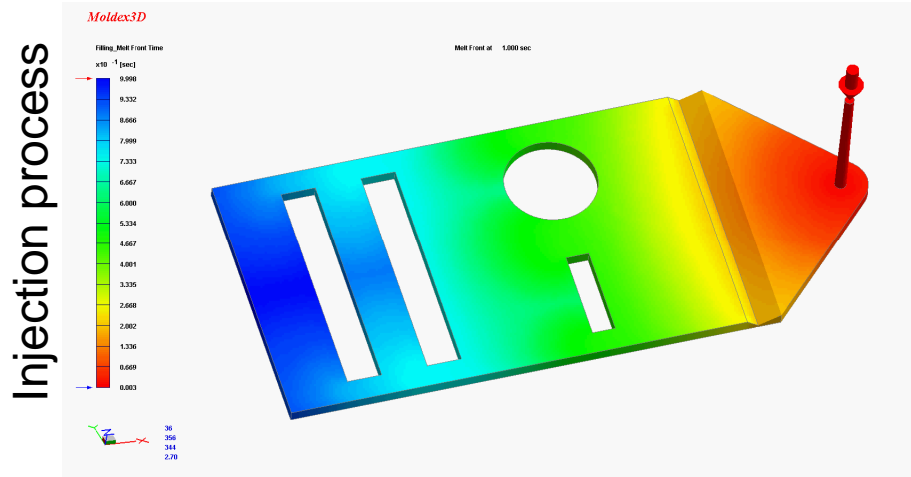


MSC Software®

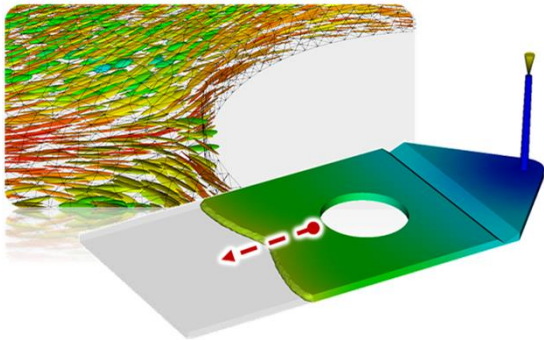


Stream
ENGINEERING
MSC Software Company

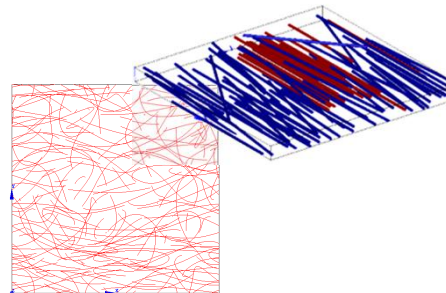
Moldex3D covers Multiple Processes and Materials



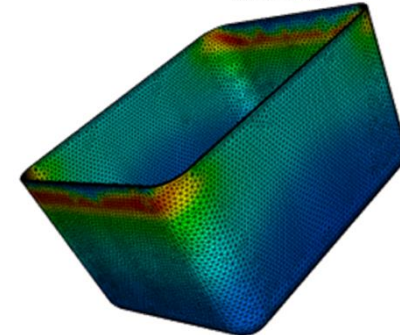
Short Fiber Reinforced Plastics



Long Fiber Thermoplastics



Mucell



Moldex3D-Digimat-MSc Software covers

- **NVH**
 - Linear Elastic

- **Stiffness**
 - Elastoplastic
 - Temperature dependent

- **Impact & Failure**
 - Elasto-Viscoplastic
 - Strain rate dependent
 - Failure model SFRP

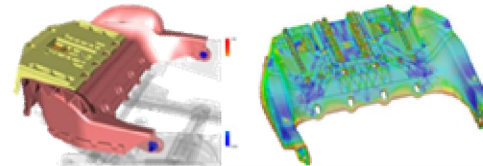
- **Creep**
 - Viscoelastic
 - Elasto-Viscoplastic

- **Durability**

Front End



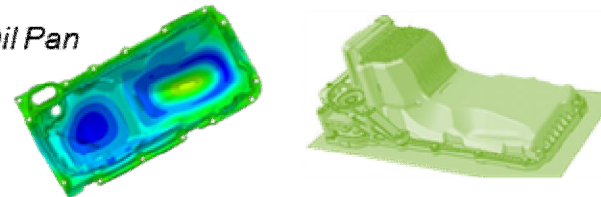
Seat pan



Engine Mount



Oil Pan



Oil Cooler Bracket



HOW CAN Moldex3D HELP YOU?

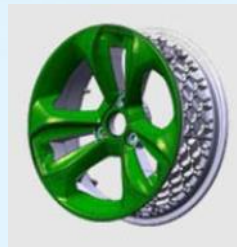
Complete Fiber Reinforced Process Portfolio

Moldex3D

Short fiber
 Long fiber
 Mat compression



Molding Compound
 Resin Transfer Molding
 Multi-component molding



Hybrid



Fabric



Mat



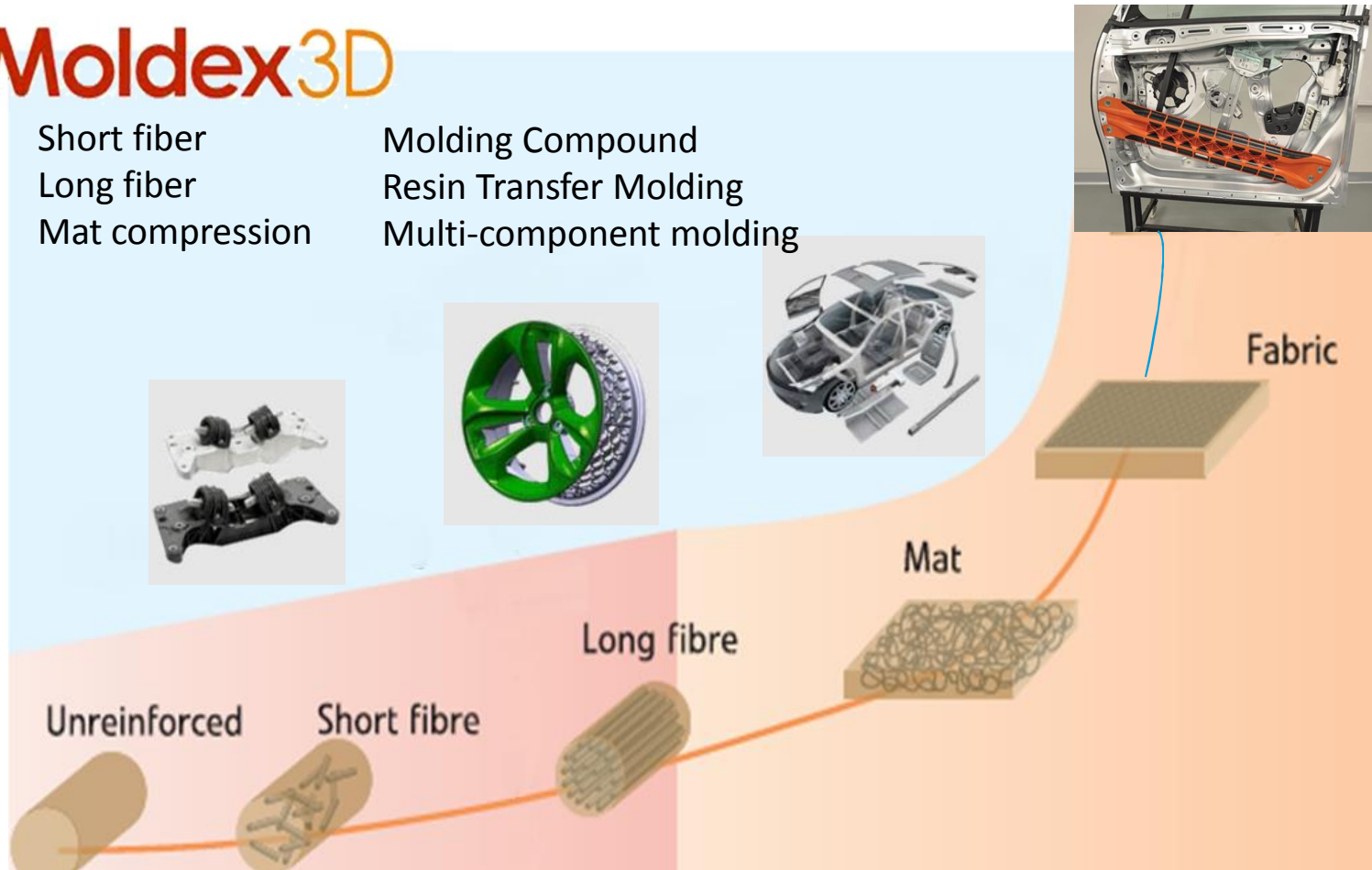
Long fibre



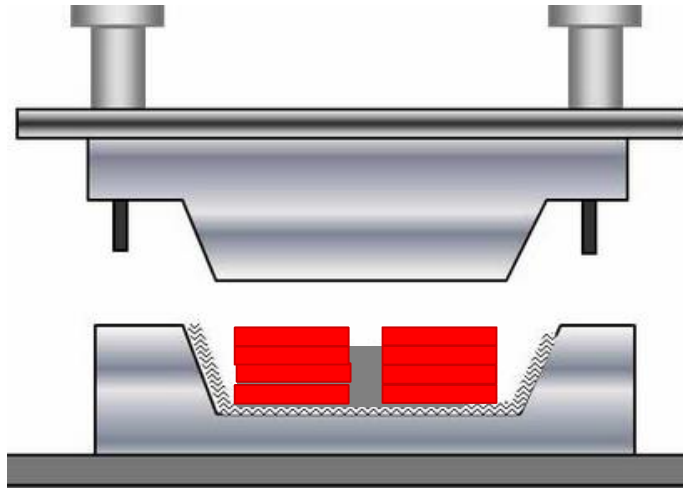
Unreinforced



Short fibre

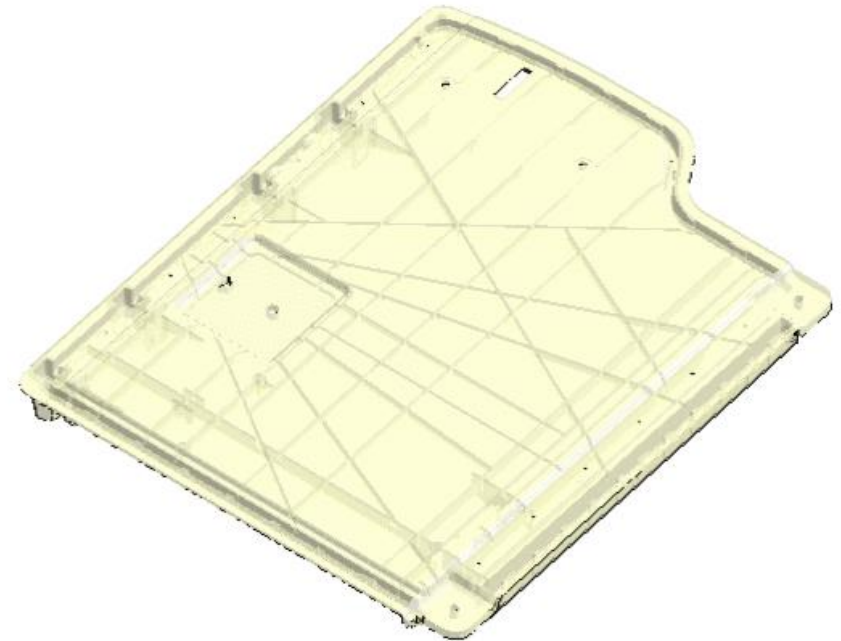


Glass mat PP compression



Filling_Melt Front Animation
Time = EOF

Melt Front at 3.952 sec



Moldex3D

43 Run 2:BLM_v8_CompressionZoneSolid.mfe/GMT_GMT_2_1.mtr/CM_DG_car_4.pro

360 At 100% (3.95 sec) (Enhanced Solver), Ep=6,601,091 Ec=0 Em=0 (FastCool) <Mixed/BLM>

39 ChargeMiddle

1.50

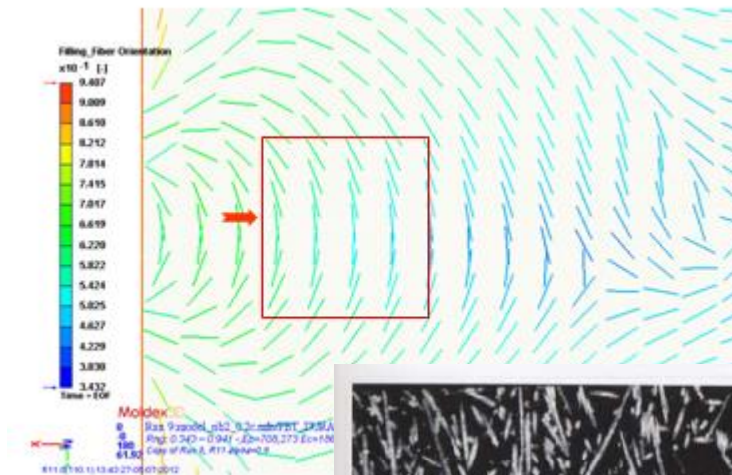
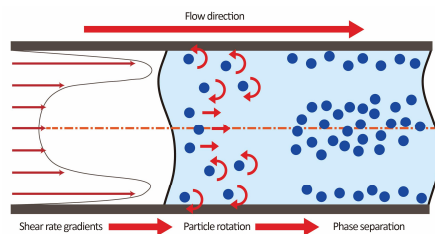
R13.0(130.1) 15:06:05-08-22-2014

0.0 200.0 mm

100.0

Elements for accurate fiber predictions

1. Flow field

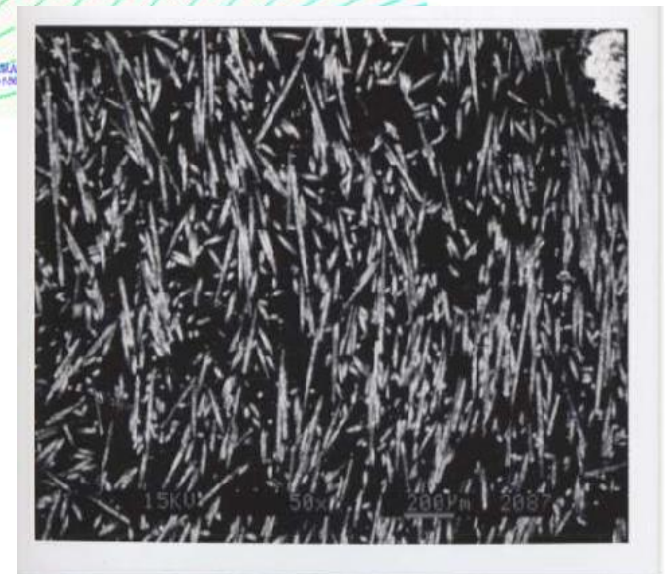
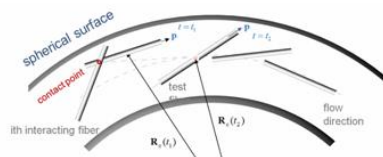


+ =

2. Orientation model

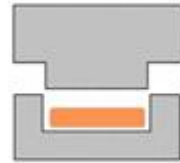
$$\dot{\mathbf{A}} = \dot{\mathbf{A}}^{\text{HD}} + \dot{\mathbf{A}}^{\text{iARD}}(C_I, C_M) + \dot{\mathbf{A}}^{\text{RPR}}(\alpha)$$

$$\dot{\mathbf{A}}^{\text{HD}} = (\mathbf{W} \cdot \mathbf{A} - \mathbf{A} \cdot \mathbf{W}) + \xi(\mathbf{D} \cdot \mathbf{A} + \mathbf{A} \cdot \mathbf{D} - 2\mathbf{A}_4 : \mathbf{D})$$

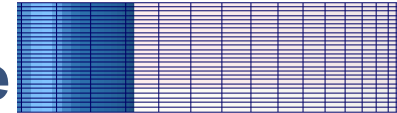


サイドゲート 場所1 10層目

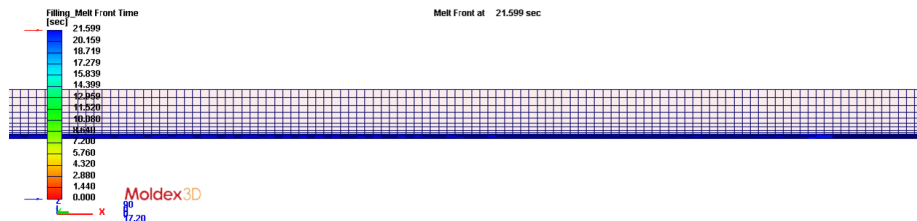
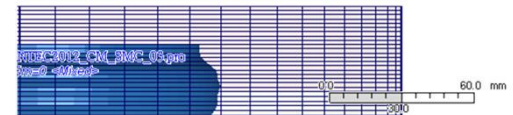
Moving mesh boundary technique



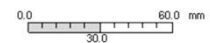
Initial charge



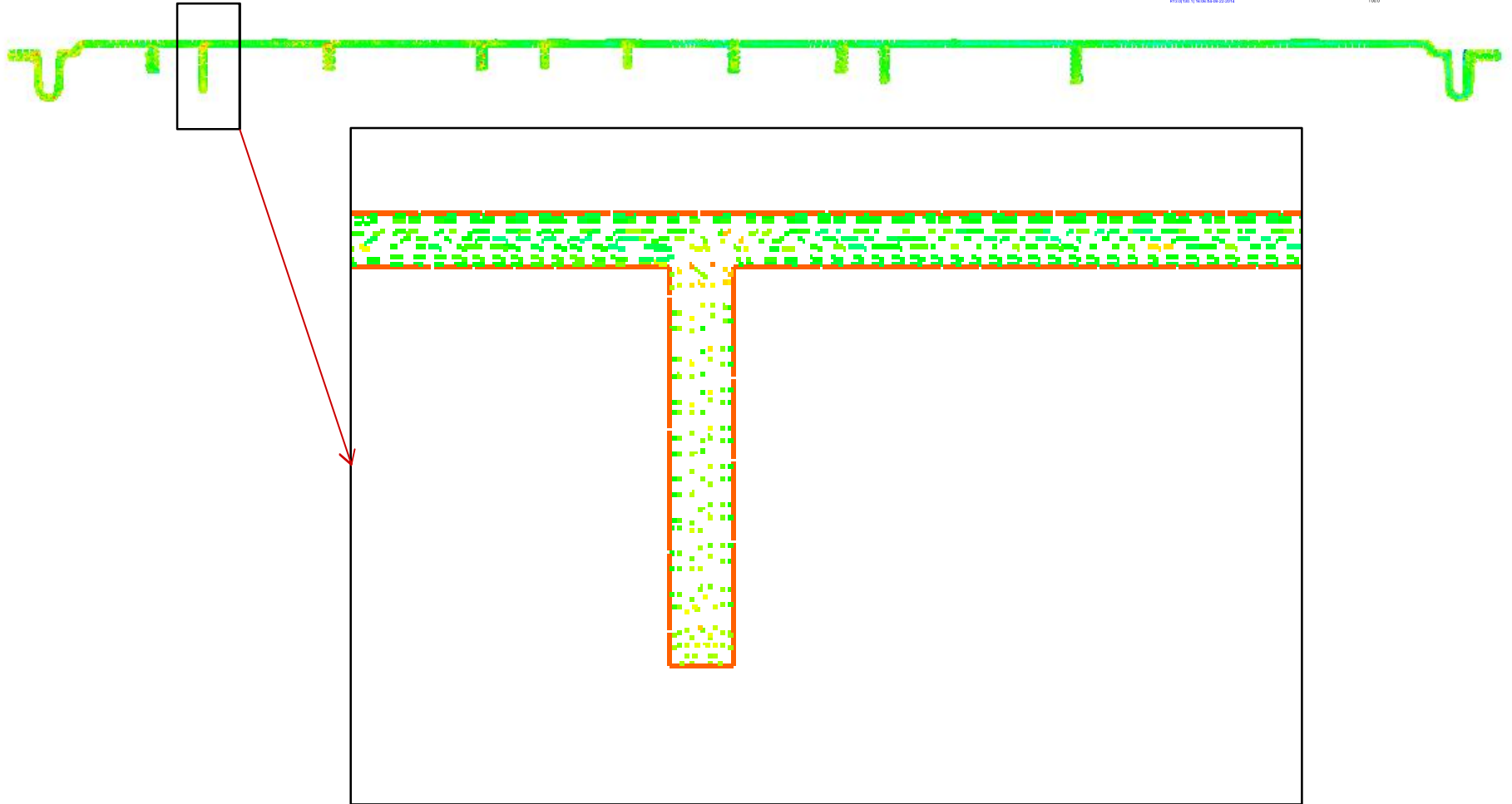
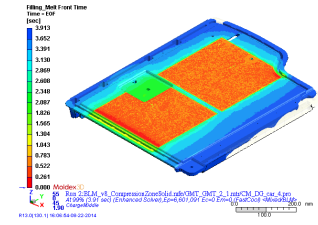
Compression zone



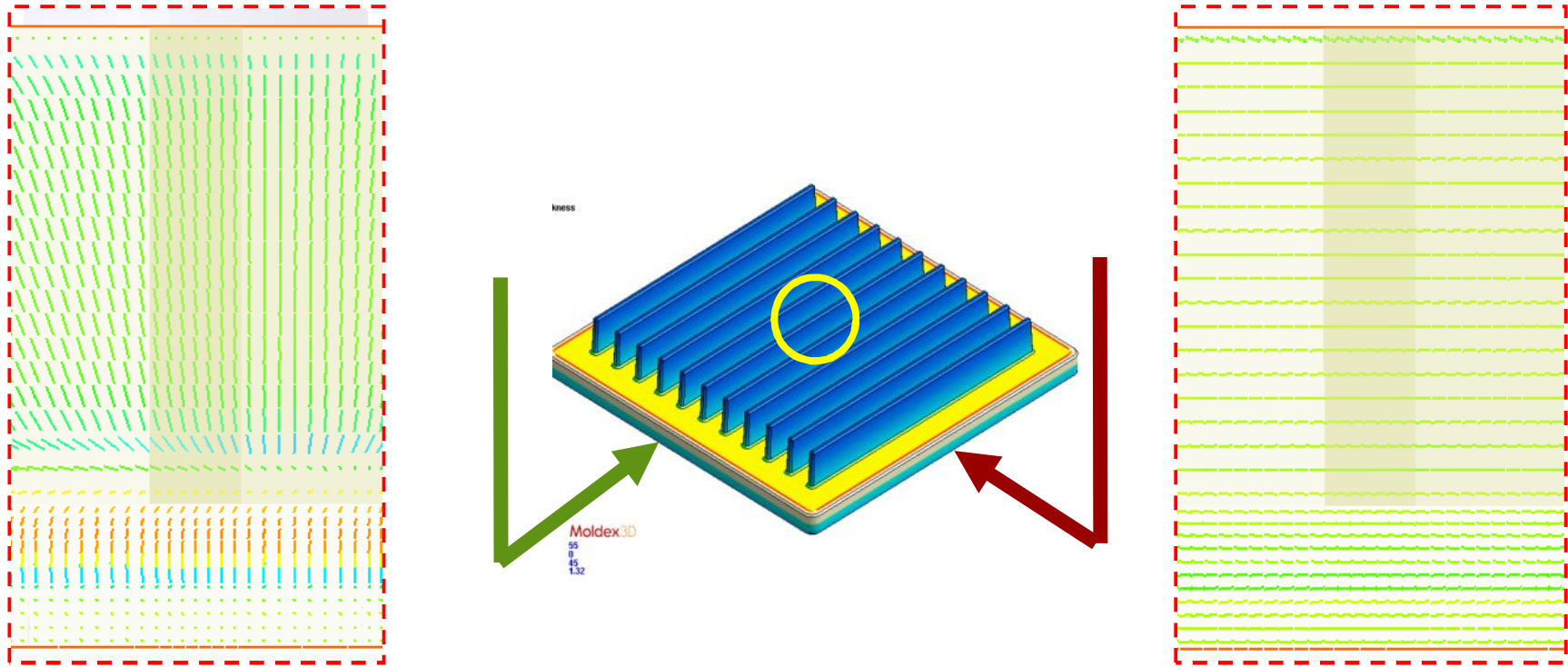
TEC2012_CM_SMC_03.pro
m=0 <Mise>



Fiber orientation after compression

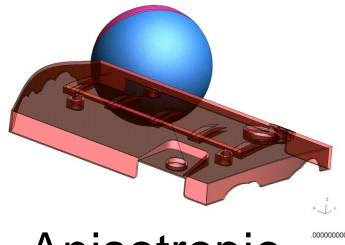


Geometry and processing conditions



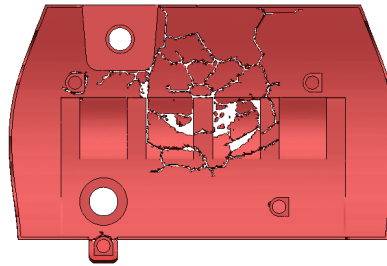
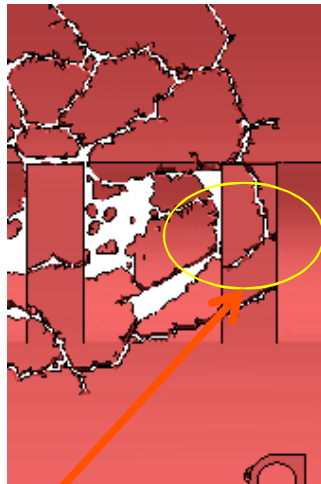
Defects considering fiber orientation

DISPLOT: Only, LDFRKA (Single Cover Impact CR6 H)

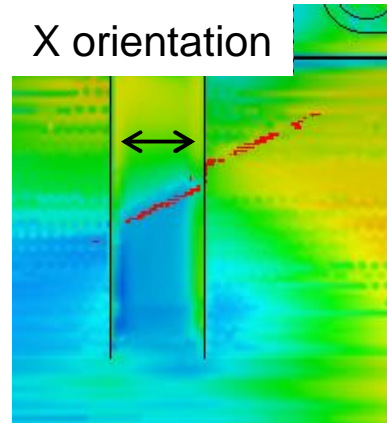


Isotropic

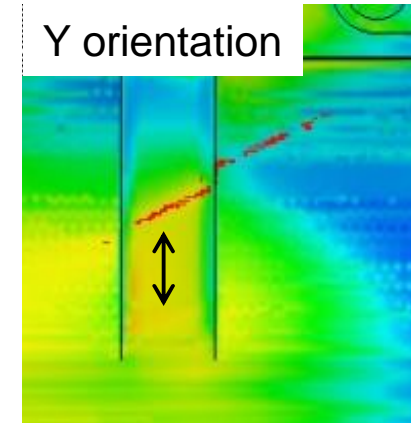
Anisotropic



X orientation



Y orientation

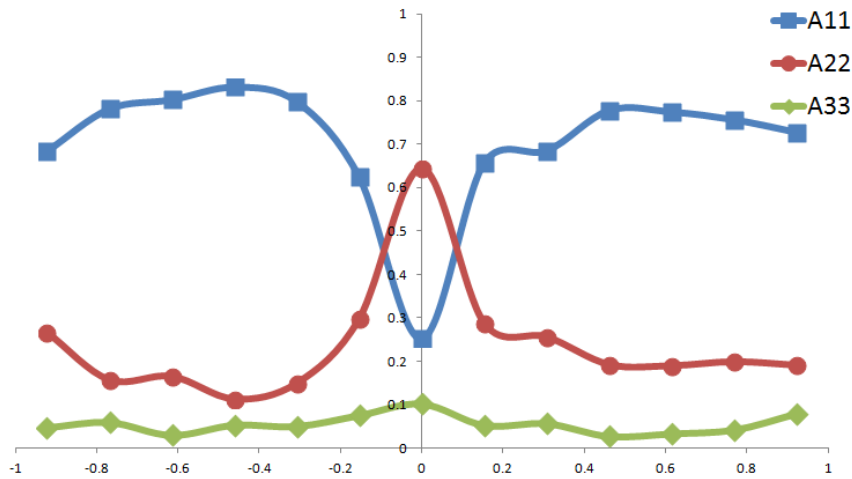


The crack propagates across the rib and follows the weldline.

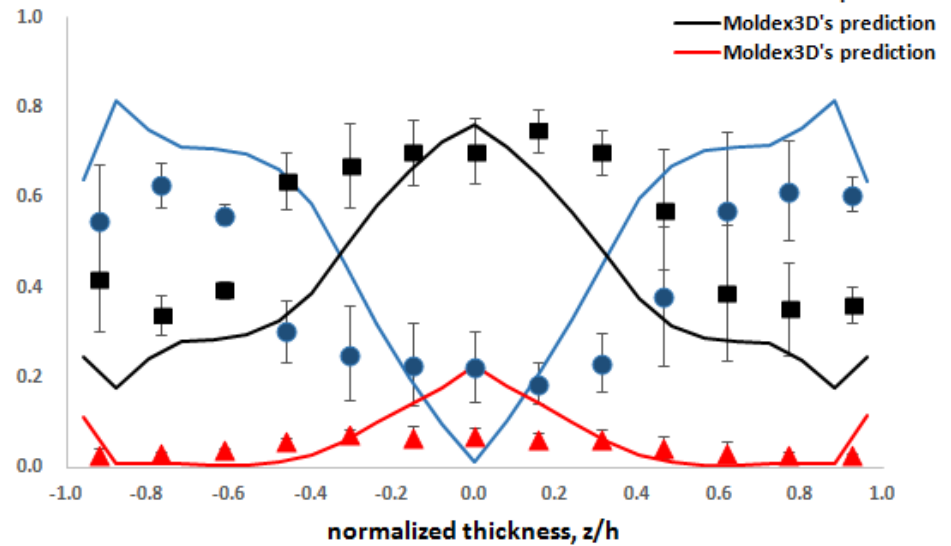
A drastic change of fiber orientation was found across the weldline. This is the main reason why crack will follow the weldline.

Good fiber model shows length effect

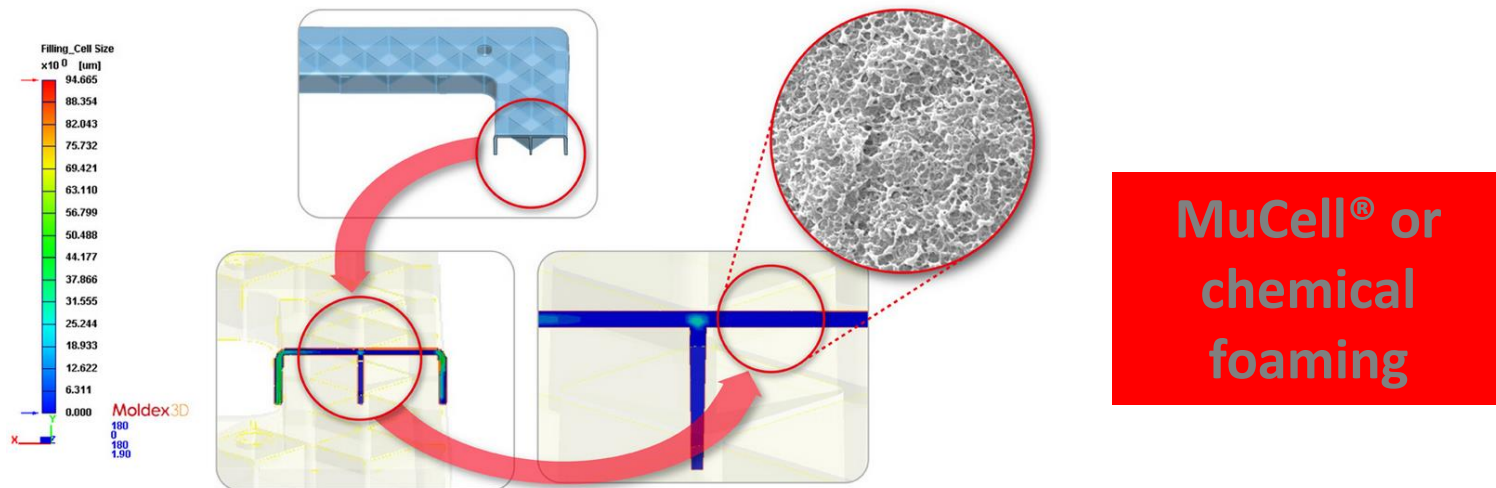
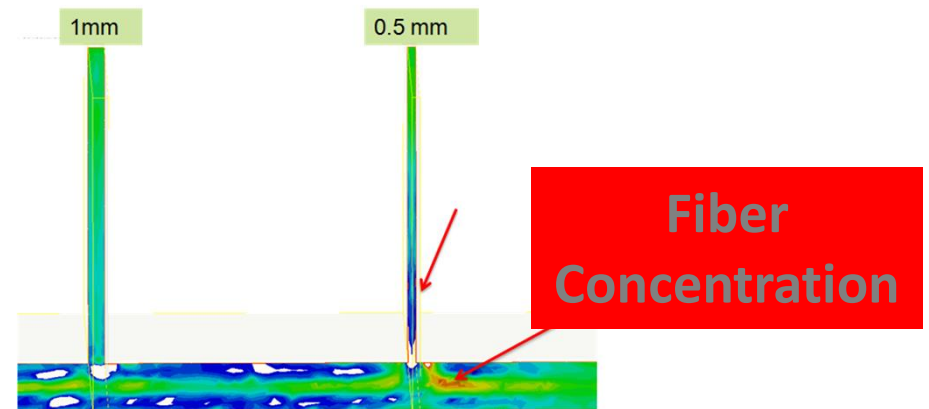
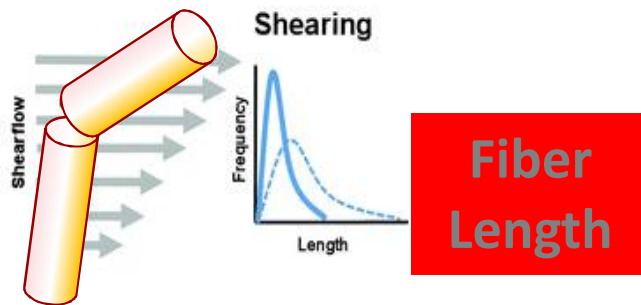
Short



Long

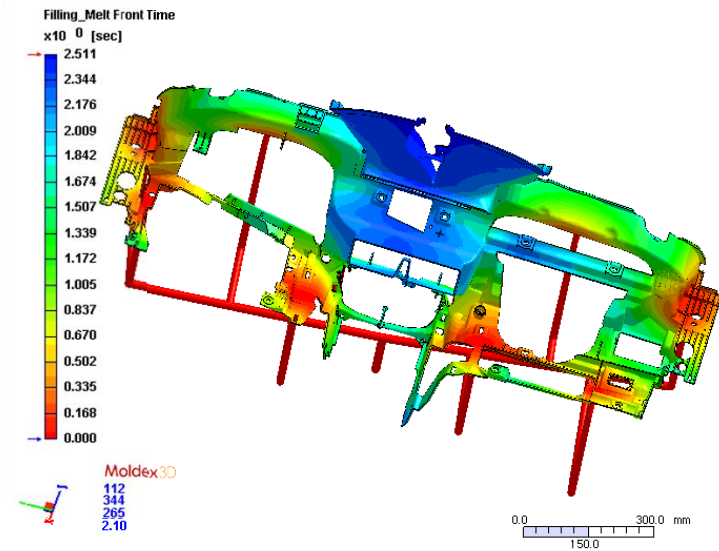


Good fiber model shows length effect

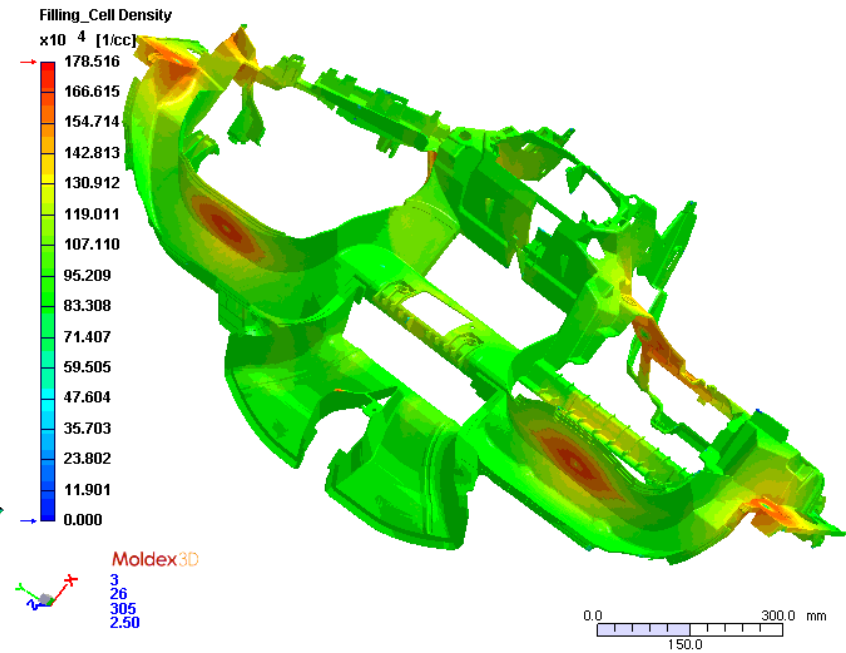
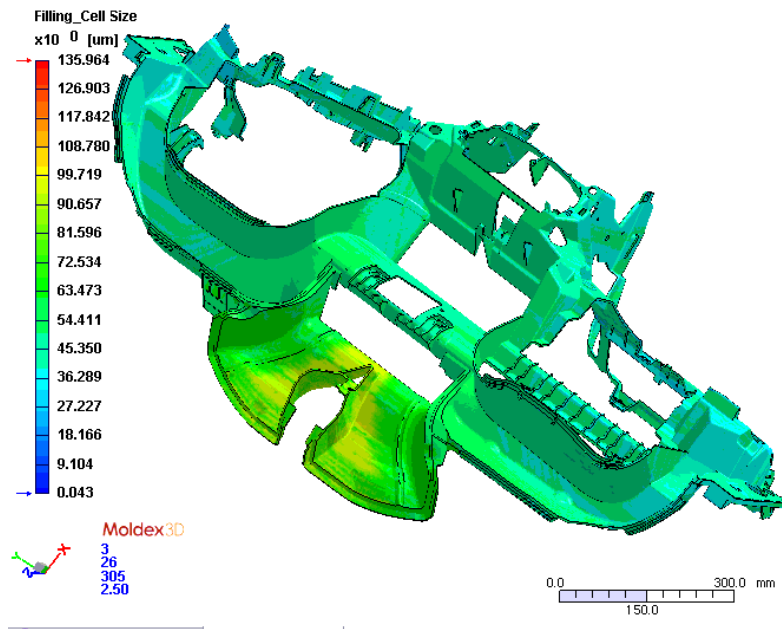


Instrumental panel using MuCell[®] technology

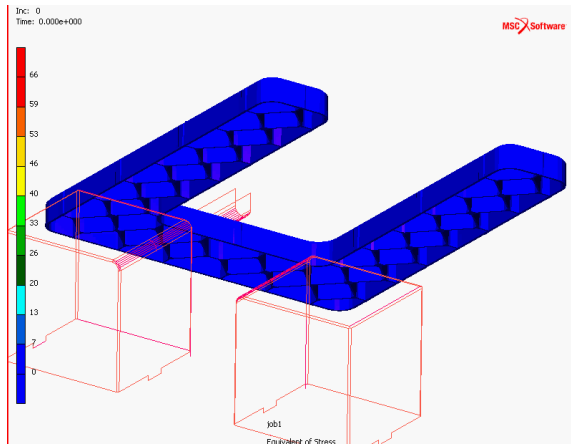
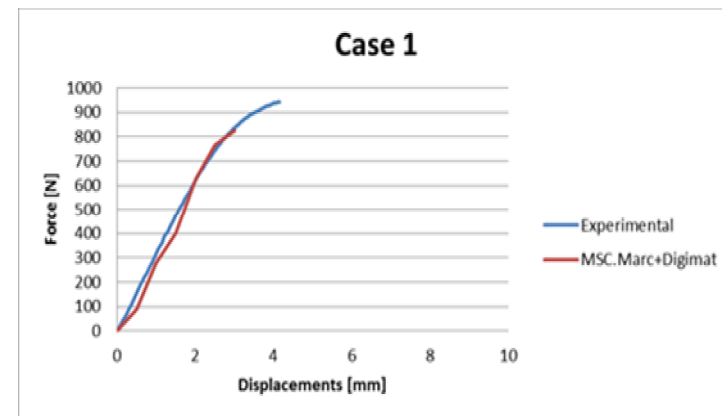
MuCell Technology Helps Ford Win the Grand Award at the 41st SPE Automotive Innovation Awards



Foaming size and cell density



MuCell[®] part strength predicitions

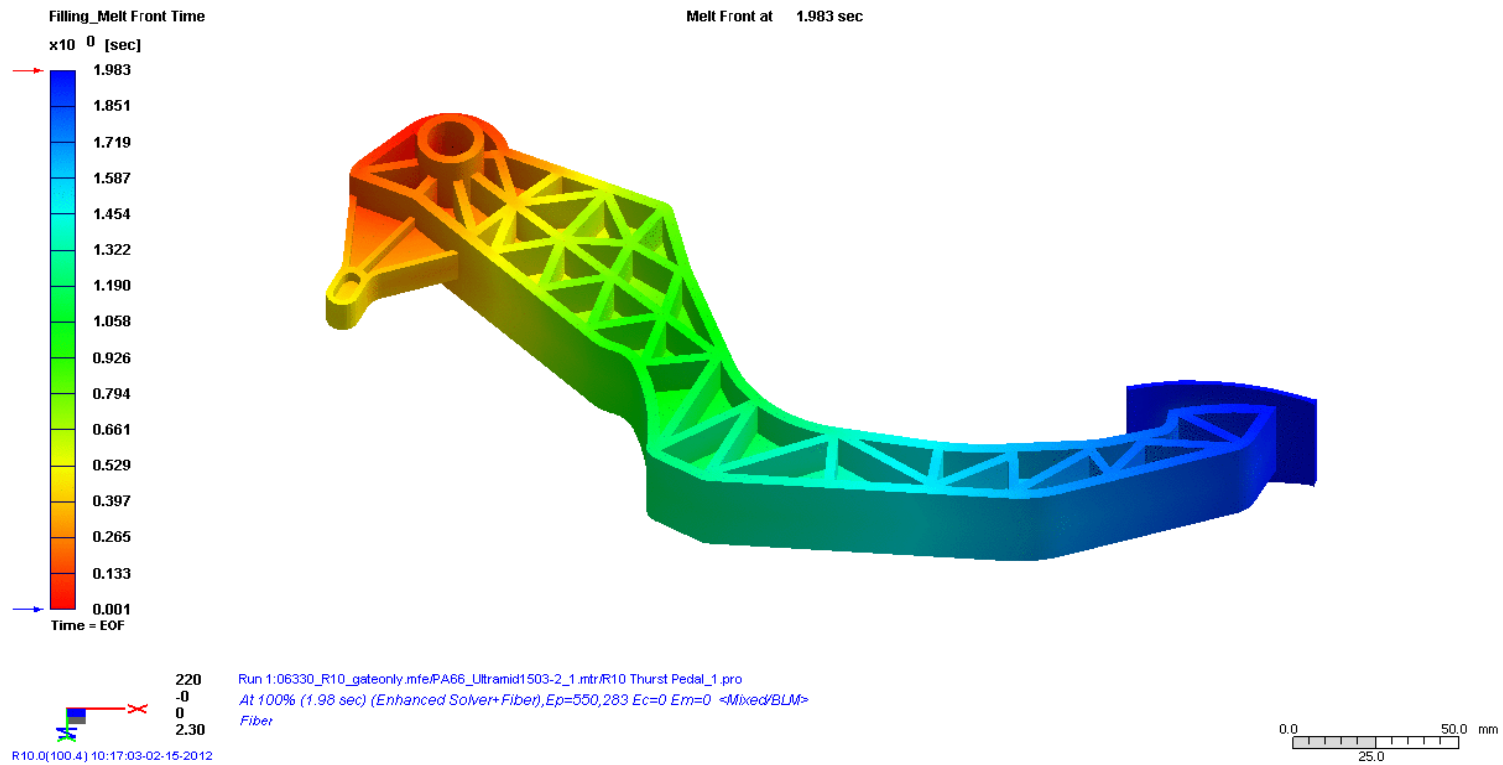


proplast
PLASTICS INNOVATION POLE

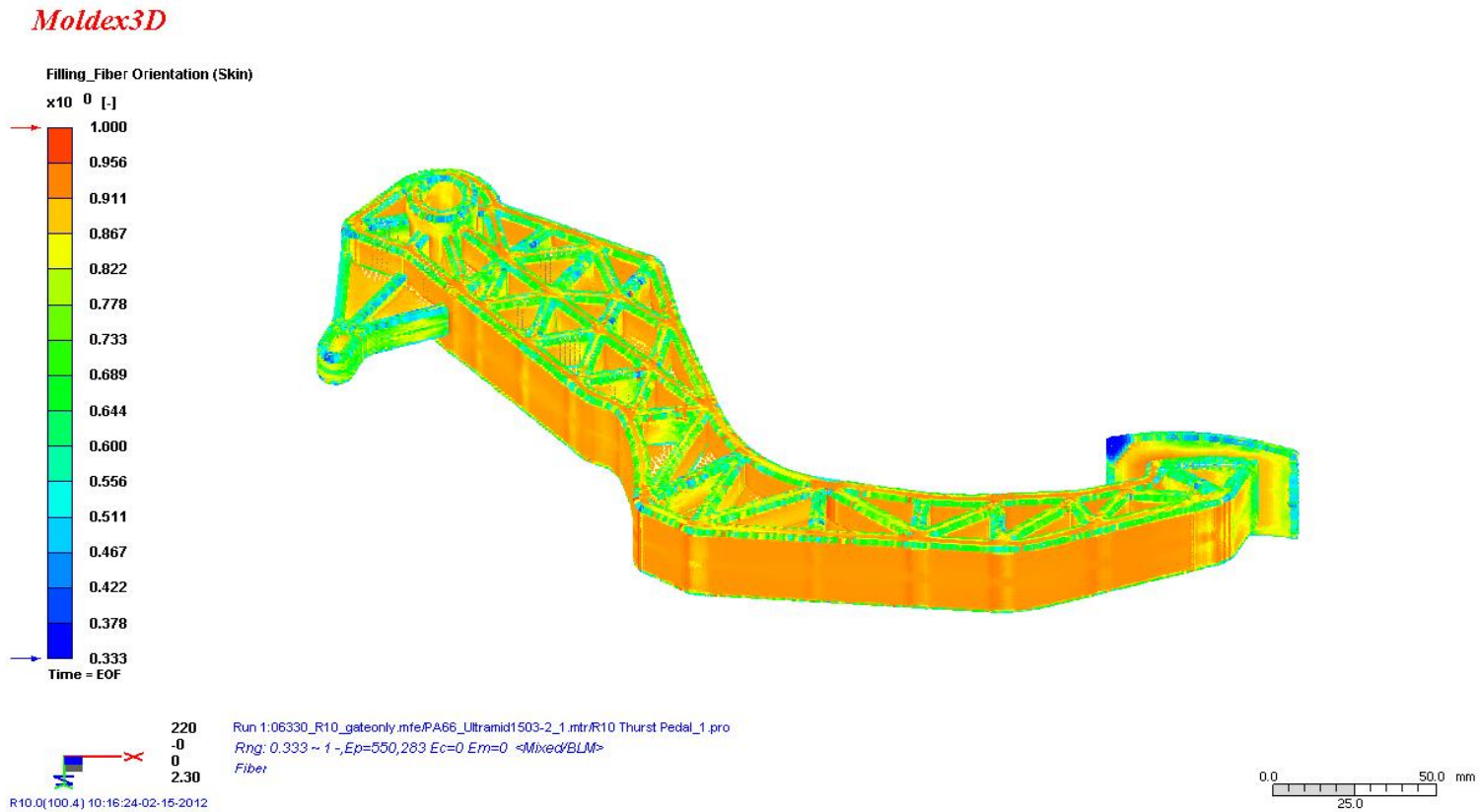
CUSTOMERS APPLICATIONS

Thrust Pedal: Injection Molding Simulation Moldex3D

Moldex3D



Thrust Pedal – Fiber Orientation

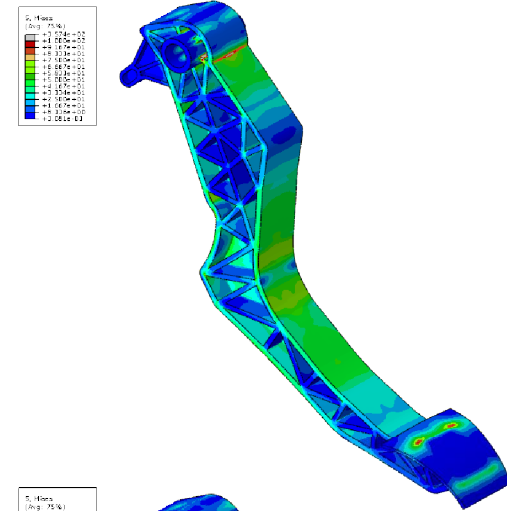
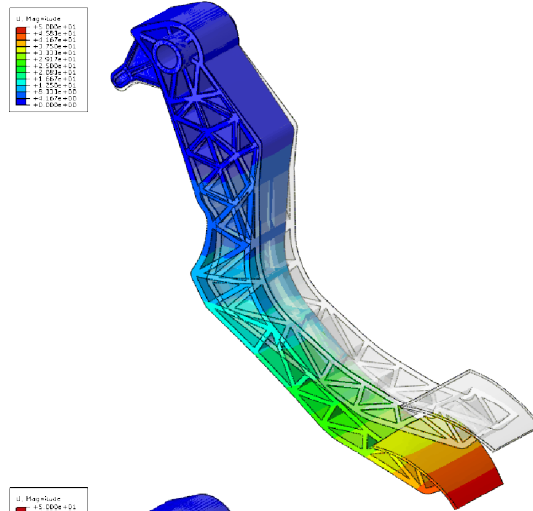


Thrust Pedal – Displacement & Stress

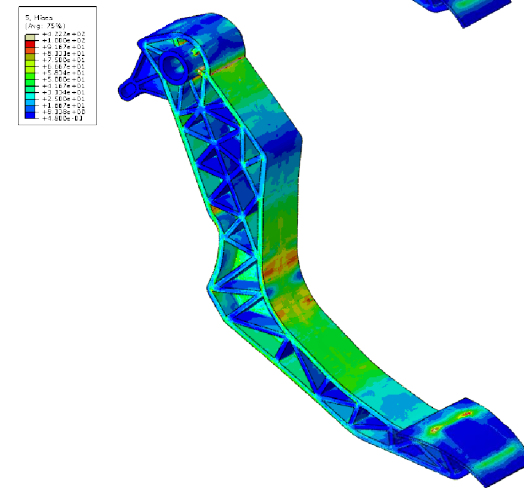
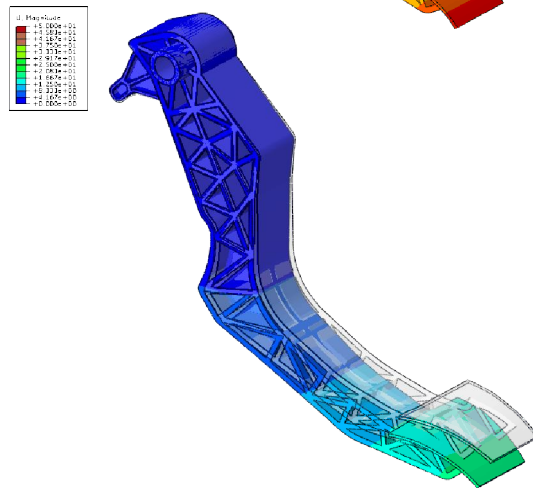
900 N Force Applied

Displacement

Stress



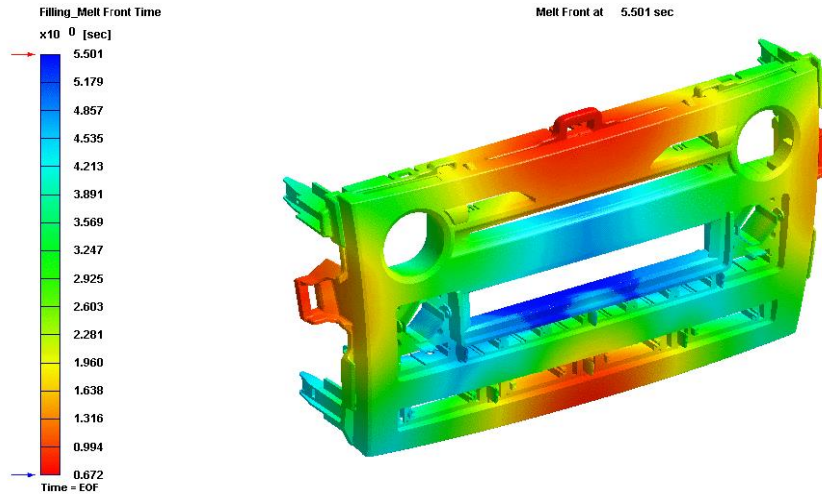
isotropic



anisotropic

Engine Cover: Injection Molding Simulation Moldex3D

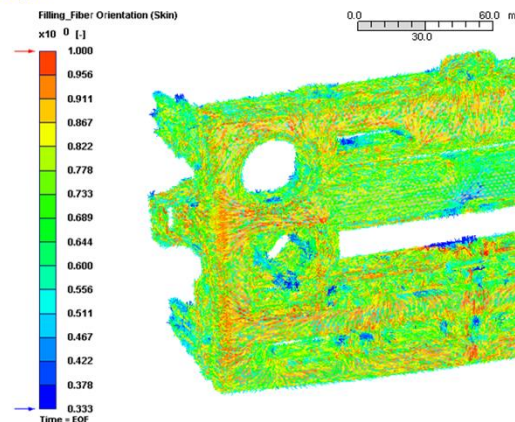
Moldex3D/eDesign



63 Run 1:R10_M4o_case_100127(m).mde/ABS_LMGABSOF20_1_intr/R10 project_1_pro
360 At 100% (5.5 sec) (Enhanced Solver+Fiber),Ep=2,259,707 Ec=288 Em=0 (FastCool) <eDesign>
56 Fiber
1.90

R10.0(100.4) 16:36:08-02:15-2012

Moldex3D



Fiber Orientation

65 Run 1:R10EngineCover_meltfrances.mde/ABS_LMGABSOF20_1_intr/R10 enginecover Solid_1_pro
359 Rng: 0.333 - 1 -,Ep=758,147 Ec=0 Em=0 <Tetra>
68 New run for without molding trial
1.24

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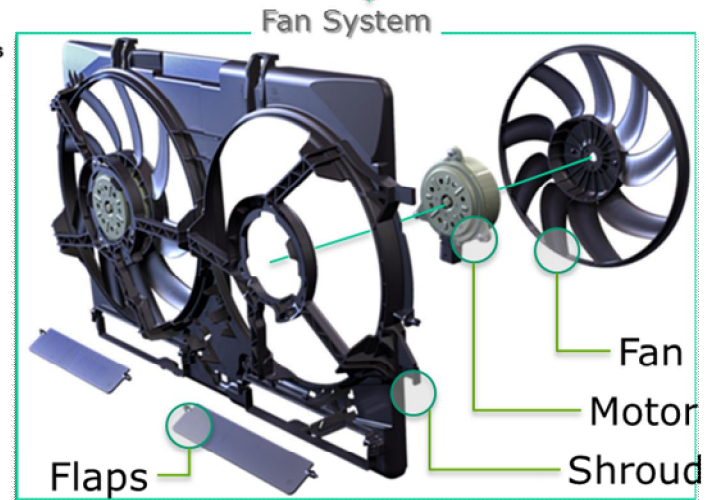
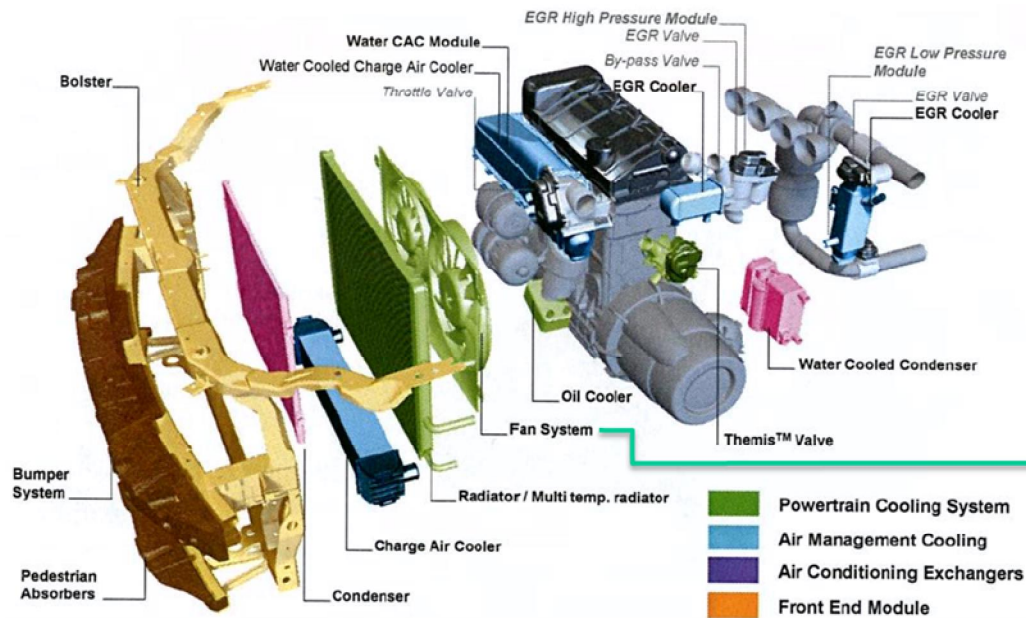
Engine Cover – Modal Analysis

Mode	Natural Frequency		Max. Displacement	
	Isotropic	Anisotropic	Isotropic	Anisotropic
1	96.0	101.4	214.9	205.1
2	322.2	329.8	245.4	220.7
3	345.0	357.3	235.4	227.4
4	410.5	423.2	311.2	288.7
5	464.9	485.8	374.5	355.3
6	616.5	641.9	320.6	310.6

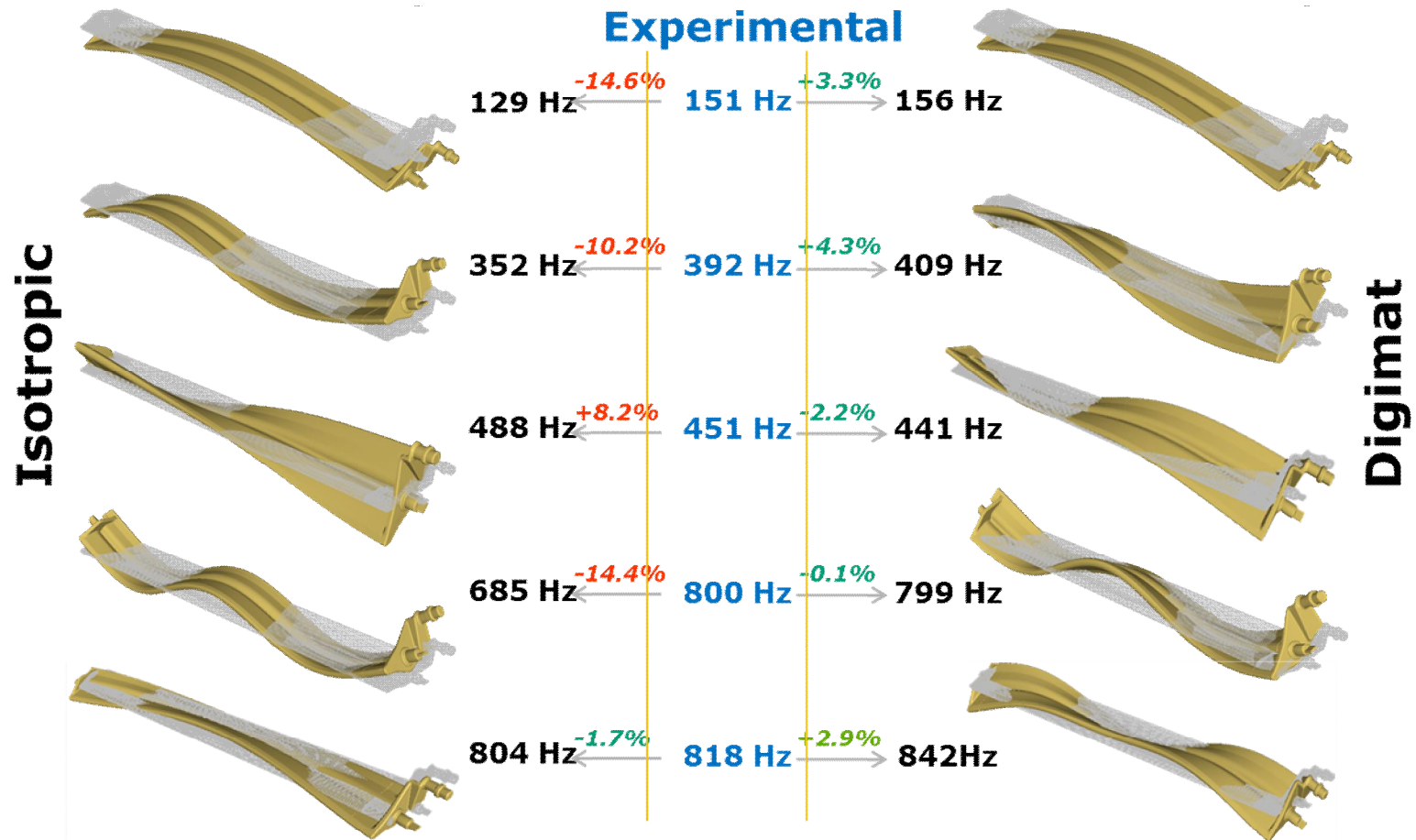
Isotropic - 1 material

Anisotropic - 7177 materials

Engine Cooling: Vibration



Flap: Modal Analysis

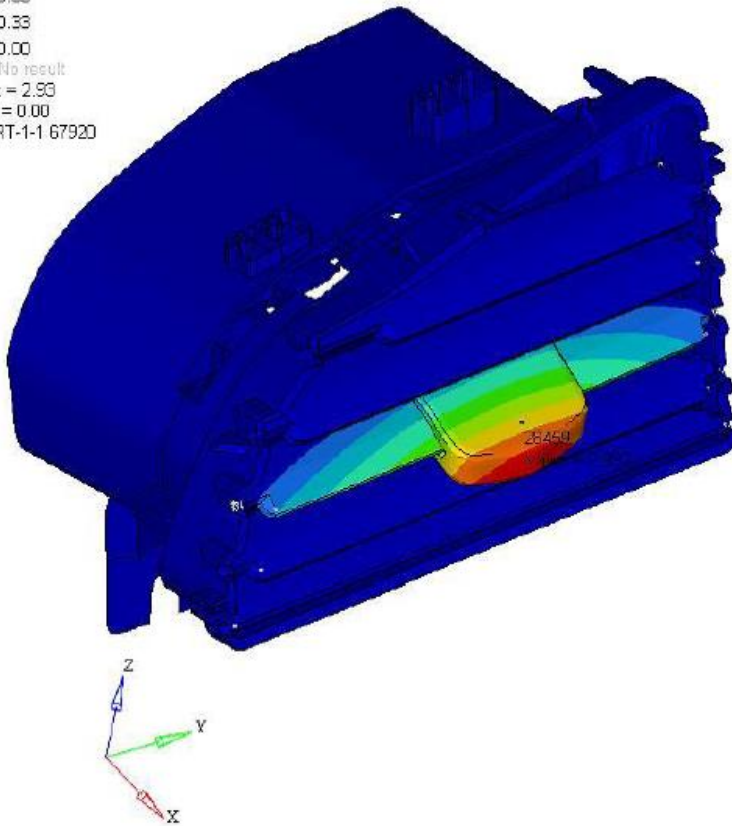


Air Duct : stiffness

Contour Plot
Displacement(Mag)
Analysis system

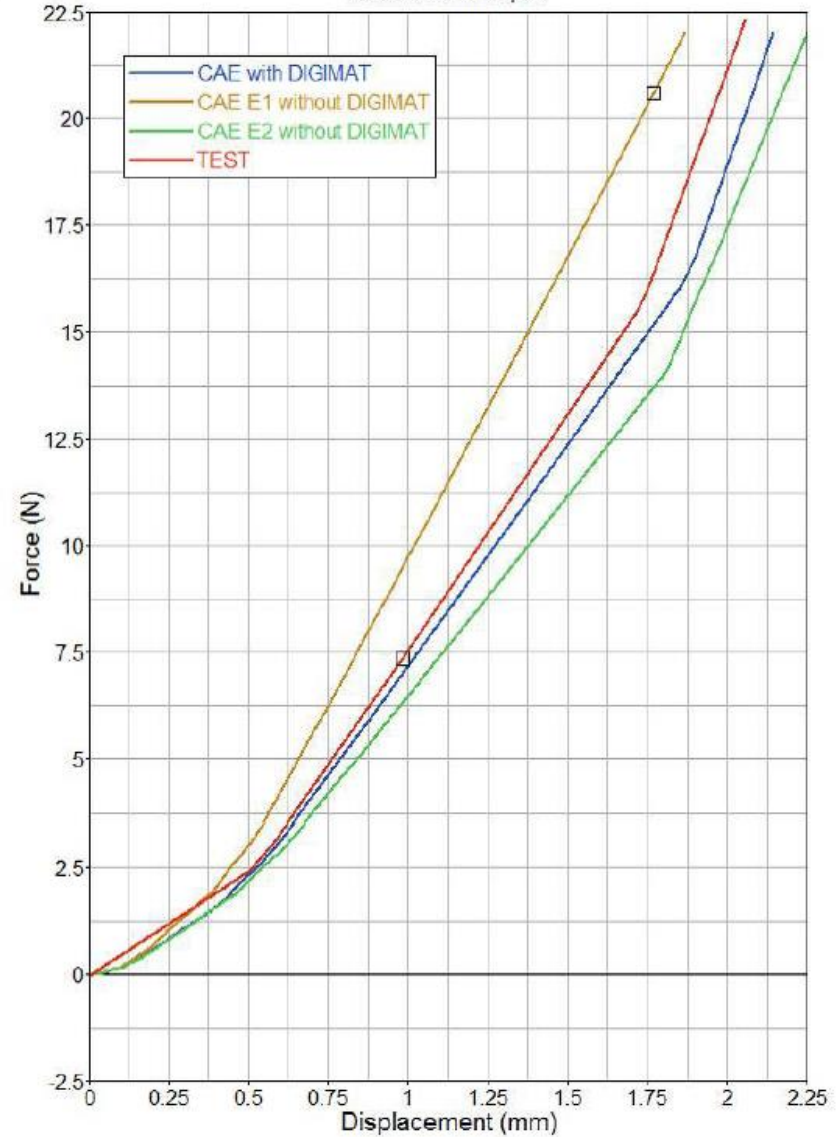
2.93
2.61
2.28
1.95
1.63
1.30
0.98
0.65
0.33
0.00

No result
Max = 2.93
Min = 0.00
PART-1-1 67920



Step-1: Increment 30: Step Time = 0.9495

Measure Group 3



Digmat: Saves \$500K to Ford!

Work in Progress



Ford Motor Co.'s advanced materials characterization process allows design engineers to improve analytical modeling and print-out of auto interior components earlier than cost or relevant characteristics (related to the concept of the 2011 model year Ford Explorer SUV).

Materials characterization

Ford engineers used the new process to analyze the stiffness of register vans on the 2011 Explorer SUV (results shown at right). The analysis that made use of an anisotropy correction via Digmat software to predict fiber orientation in the finished part provided the best correlation to actual measured data.




reinforced materials, this was not the case — values measured at 90° to the flow could be as much as 60 percent lower than values in the flow direction. Using datasheet properties, then, could lead to overly optimistic estimates of mechanical properties across a part, particularly one with great geometric complexity. So an engineer either built in a big safety factor (e.g., thicker wall sections, which added to per-part cost and weight) or opted for the expensive and time-intensive make-and-break method to determine material usage. Similarly, everyone knew that despite the monolithic datasheet values, the actual materials were strain-rate, temperature and load dependent. So if an engineer was estimating how a part would behave at a different time, temperature, strain rate or load than was used to measure properties on test specimen via a standard DCP test method, there was an inherent need to not the under-

pot City, Taiwan). This preliminary analysis gives a design direction — that is, it helps set wall thicknesses, indicates where additional structures (e.g., ribbing) might be needed to boost stiffness, etc.

A second step is used for reinforced plastics. It involves what

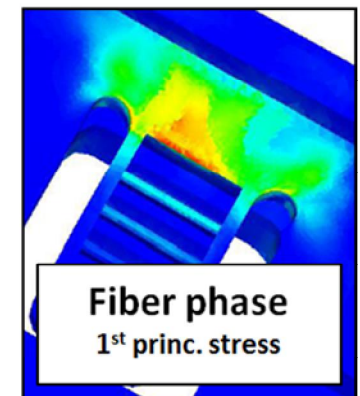
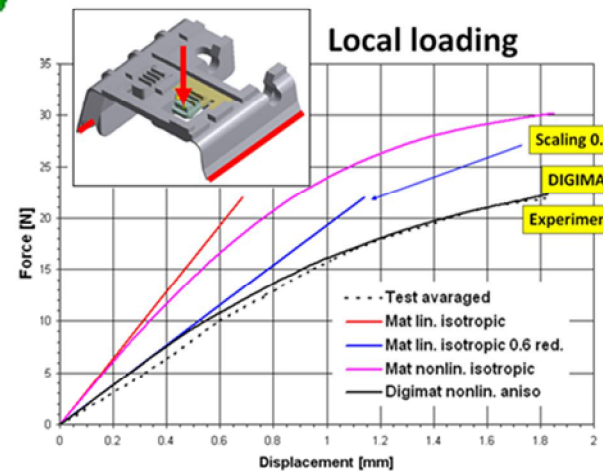
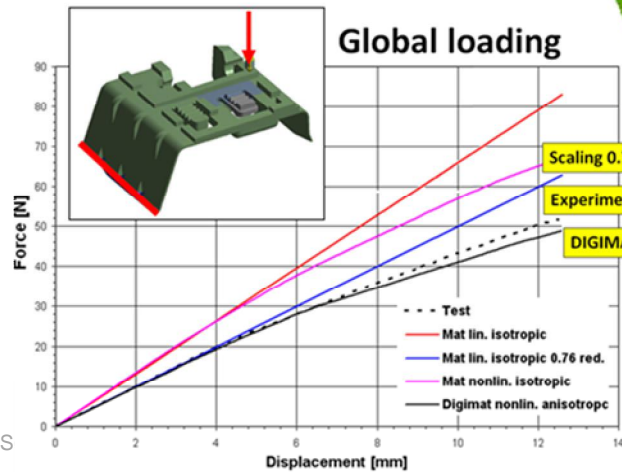
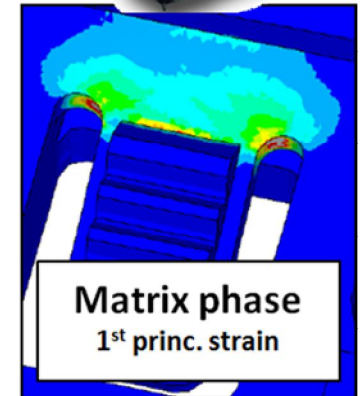
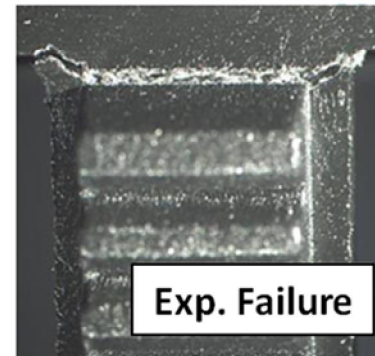
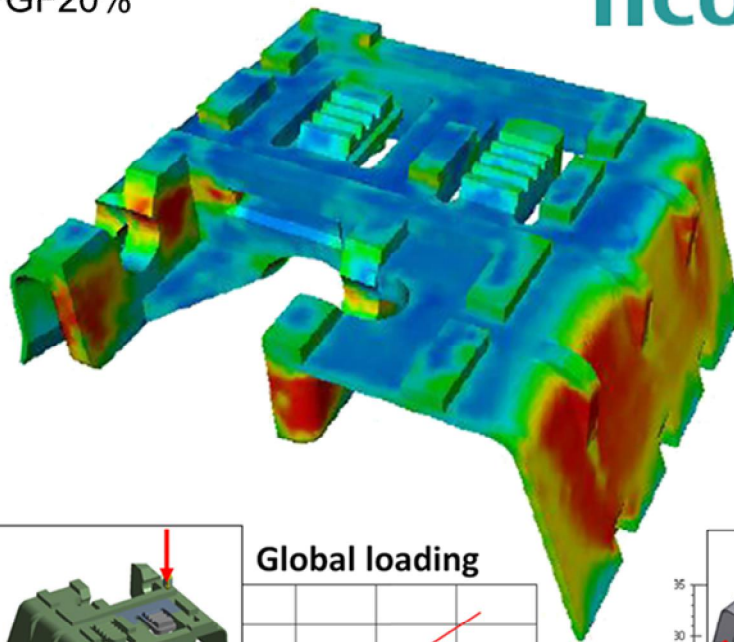
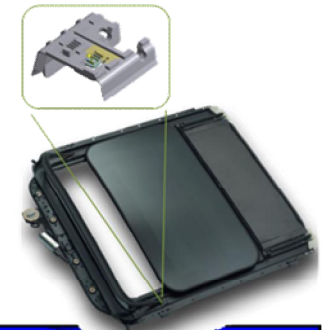
injection, blow, microcellular-foam or compression molding. This enables engineers to design interior parts closer to their materials'



Roof System Bearing: Stiffness & Failure

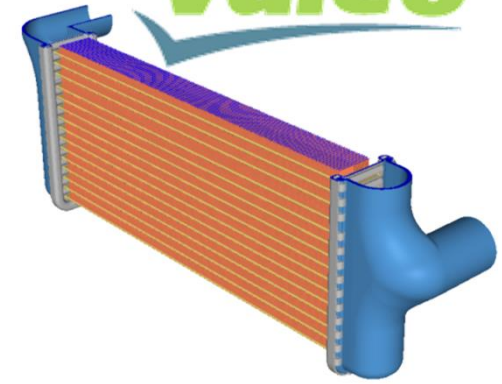
PPGF20%

Ticona INTEVA PRODUCTS



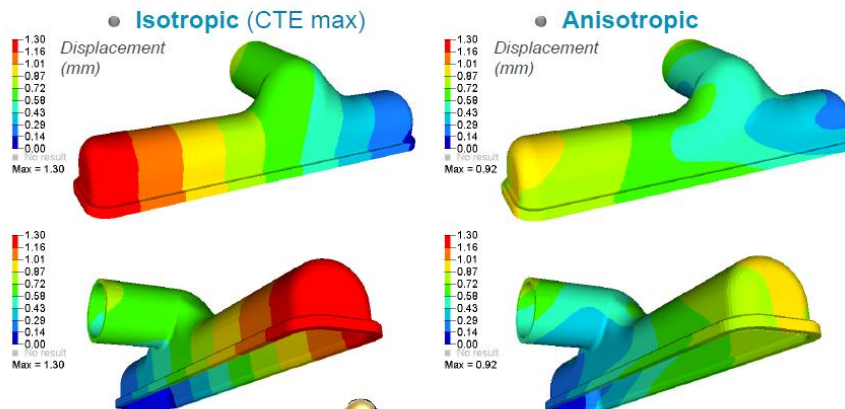
Performance: Stiffness & thermal behavior

É Thermo-mechanical behavior of vehicle heater exchangers



Thermo-mechanical Analysis (Isotropy vs Anisotropy)

- Water Tank (Reinforced Plastic) only



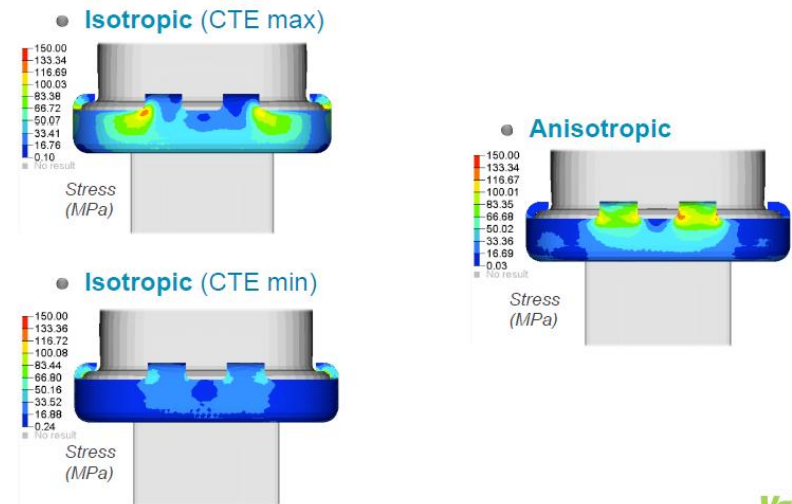
Magnitude and shape are different

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Thermo-mechanical Analysis (Isotropy vs Anisotropy)

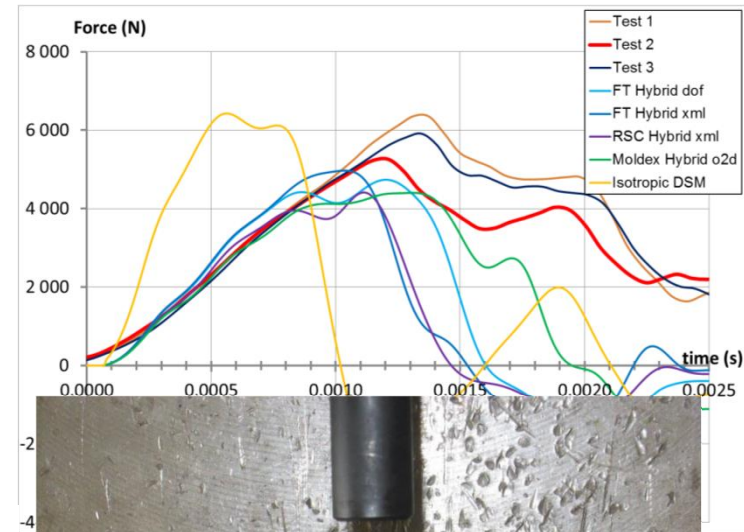
- Plus Internal Pressure Load



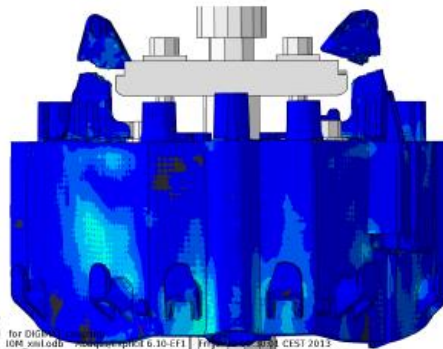
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Performance: Airbag Housing Strength in Deployment



✓ The failure with DIGIMAT HYBRID 4.4.1 occurs in hooks heads, like in the test



Digimat USERS' MEETING 2013

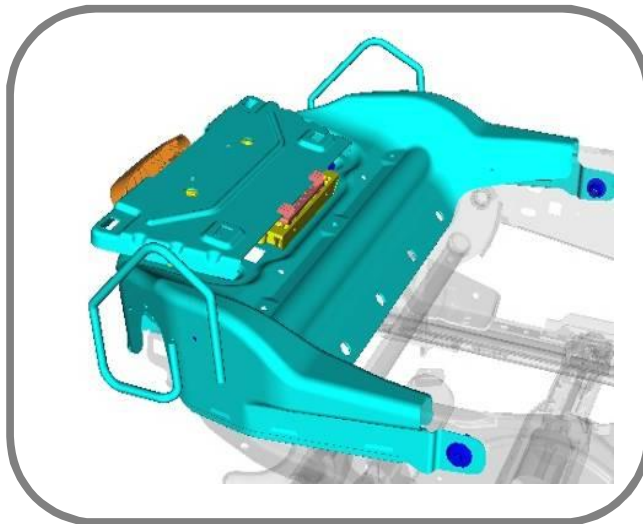
Faurecia Seat - Design of SFRP

É Challenge

- Metal replacement by TECHNLYL®

Reference Seat

All steel

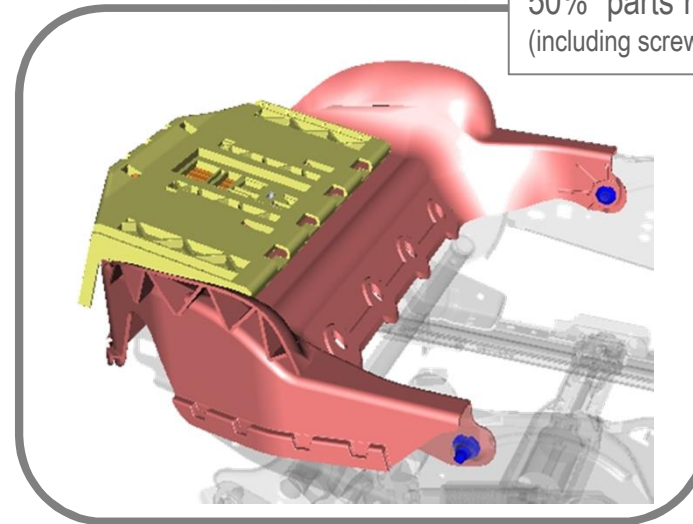


Cushion length adjustment and powered tilt function

2750 g

Multifunctional Seat Pan

Injected PA6/GF30



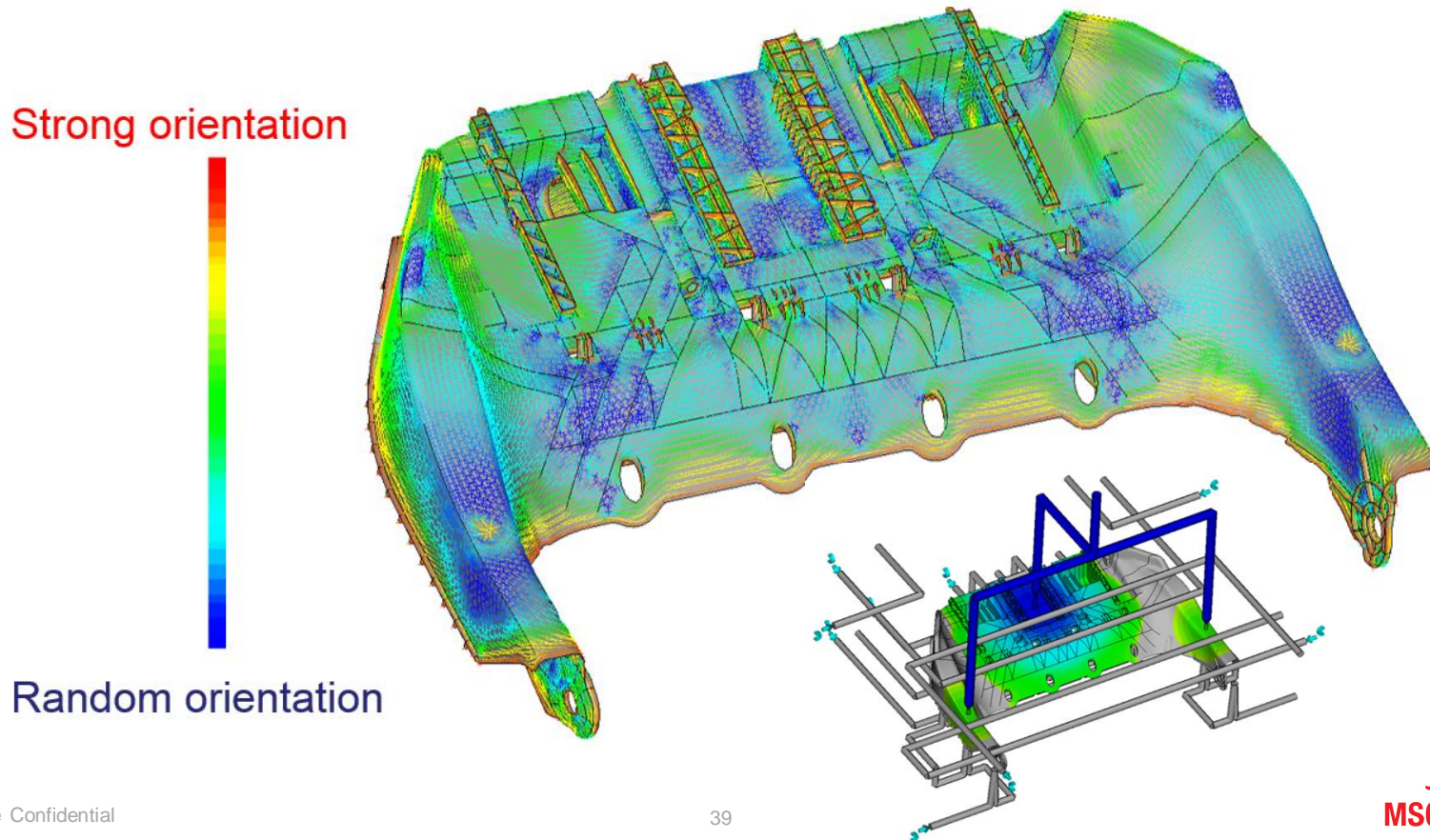
50% parts reduction
(including screws and rivets)

Same functionality

1665 g

Faurecia Seat - Design of SFRP

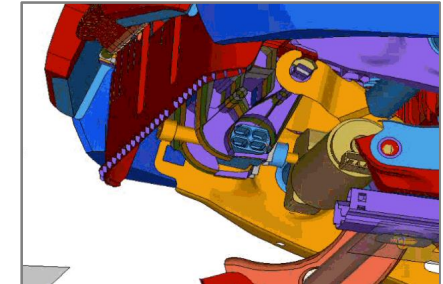
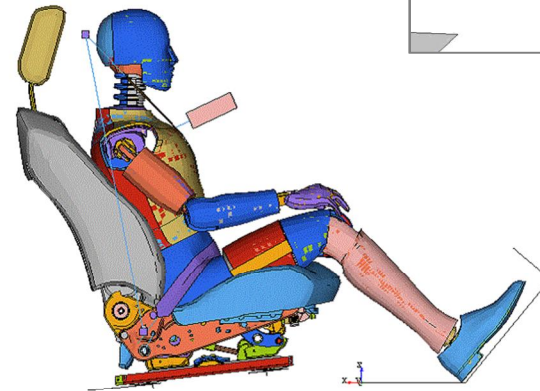
É Injection Molding Part



Faurecia Seat - Design of SFRP

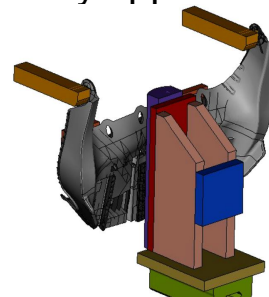
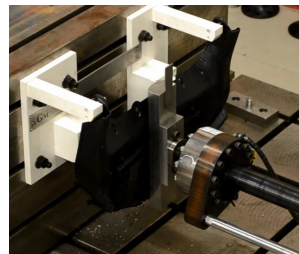
É Simulation Strategy

- . Complete front crash test and simulation (65 km/h)
 - É Tests performed at Faurecia facilities
 - É LS-Dyna explicit analyses at Solvay



- . Investigation of a simple sub-system

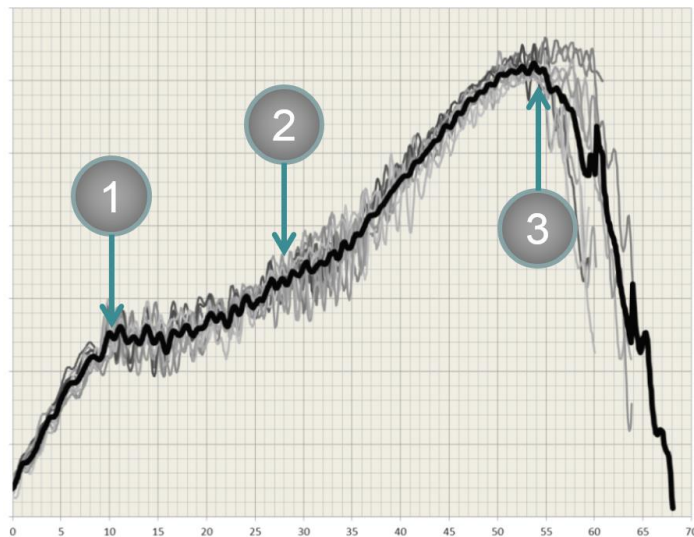
- É Tests and simulation performed at Solvay application development laboratory



Faurecia Seat - Design of SFRP

É Failure Correlation

- Focus on 3 significant events
 - É Rib buckling
 - É Rib failure
 - É Failure evolution



Faurecia Seat - Design of SFRP

É Failure Correlation

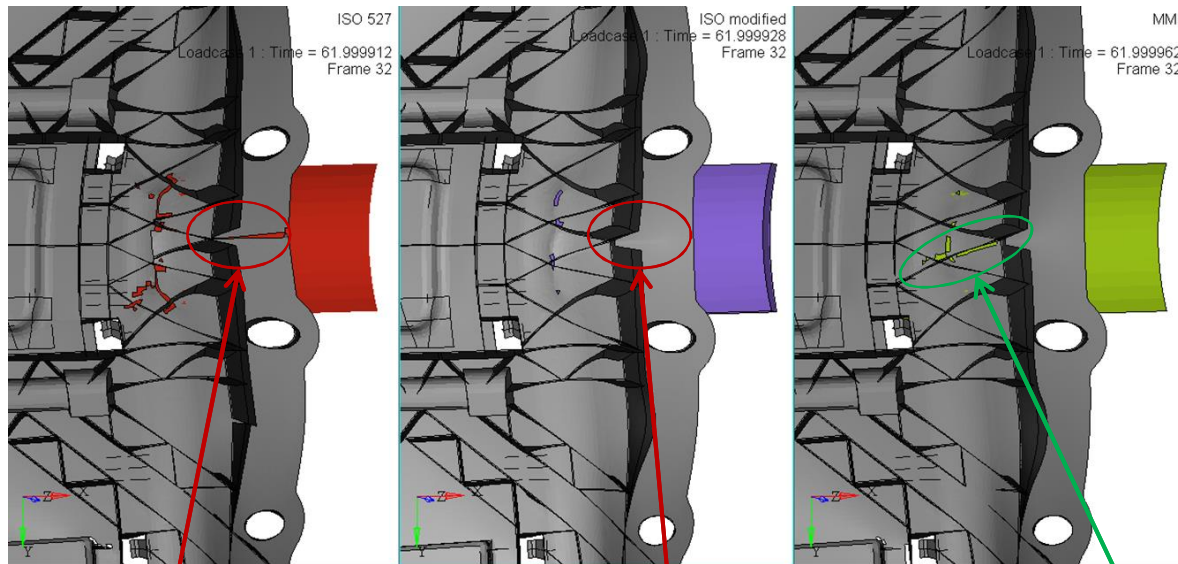
. After 54 ms: first failure evolution

Standard

Empirical

MMI

Experiment



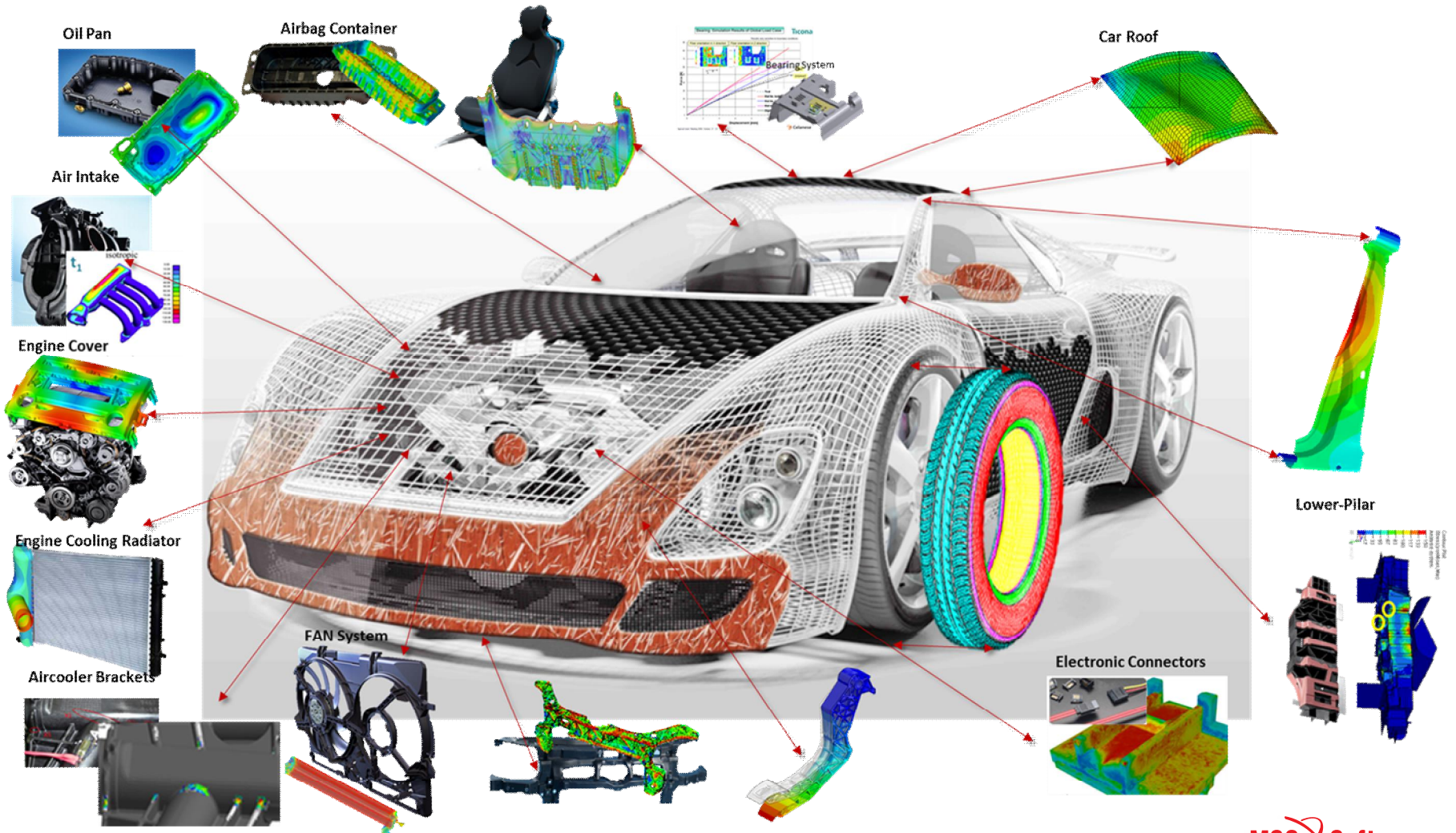
Failure goes in wrong direction.

Failure stops. Wrong prediction.

Failure continues following rib base, Good prediction.



And many other applications



CONCLUSION

Moldex3D-Digimat-MSC offers an End-to-End Solution to accurately model

- Multiple Materials (SFRP, LFRP, MuCell)
- Multiple Processes (Injection, Compression, MuC)
- Multiple Performances (NVH, Stiffness, Impact, Failure, Creep, Fatigue, ..)
- Multiple Applications (Automotive, E&E, Aerospace, consumer goods)
- Multiple Scales (Material, Component, System)

This solution is validated and adopted by hundreds of companies worldwide

THANK YOU !!