

**ADOPT INJECTION MOULDING  
MANUFACTURING EFFECTS TO  
IMPROVE PARTS' CRASHWORTHINESS**

# Problem

Increase the crashworthiness of plastic parts

- Big and complex parts vs local fiber orientation (SFRP)



# Proposal

Consider Injection Molding manufacturing effects



- Fibers' orientation
- Weld lines

# Why?

Fiber orientation

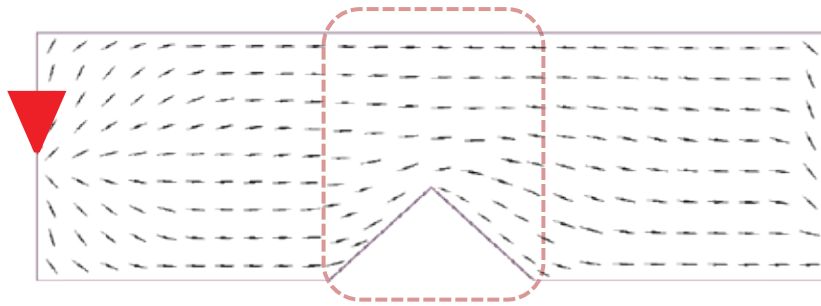


Orthotropic properties

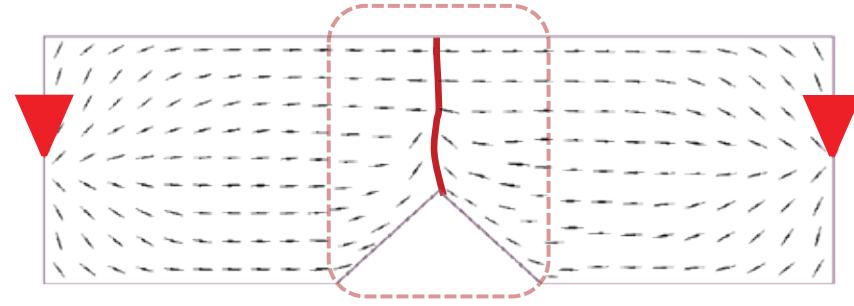
Weld lines formation



Poor mechanical properties

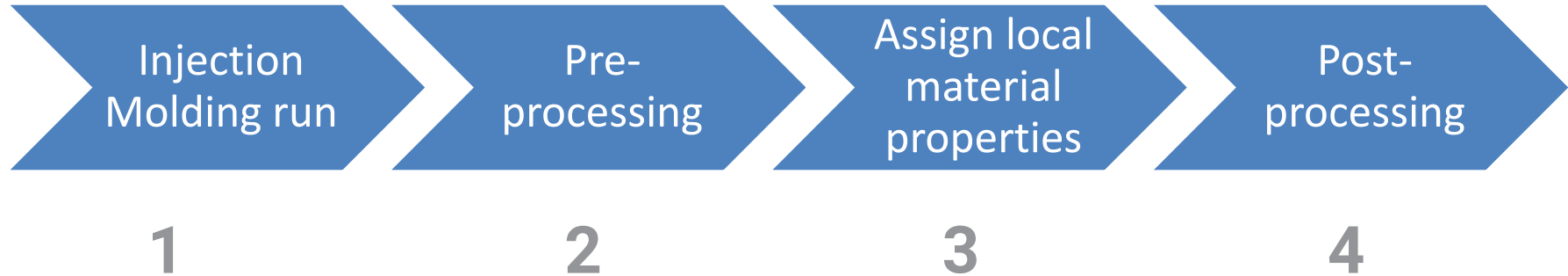


*One-gate run*



*Two-gate run*

# Solution



01

**ANSA**   
PRE PROCESSOR

02

**MF GenYld  
+  
CrachFEM**

03

**META**   
POST PROCESSOR

# **1. *The CAE process***

2. One-step injection molding

3. Pre-processing the results

4. CrachFEM material model

5. Simulation results

6. Conclusions

**META**  
POST PROCESSOR

MF\_GenYld  
+  
CrachFEM

# Optimization

Store results  
to model

**ANSA**  
PRE PROCESSOR

**M** MOLDFLOW

**Moldex3D**  
MOLDING INNOVATION

*\*INITIAL\_STRESS*





1. The CAE process
- 2. *One-step injection molding***
3. Pre-processing the results
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# Objective

## Early design stage product development

- Quick setup
- Standard capabilities
- No extra resources

# Quick & easy

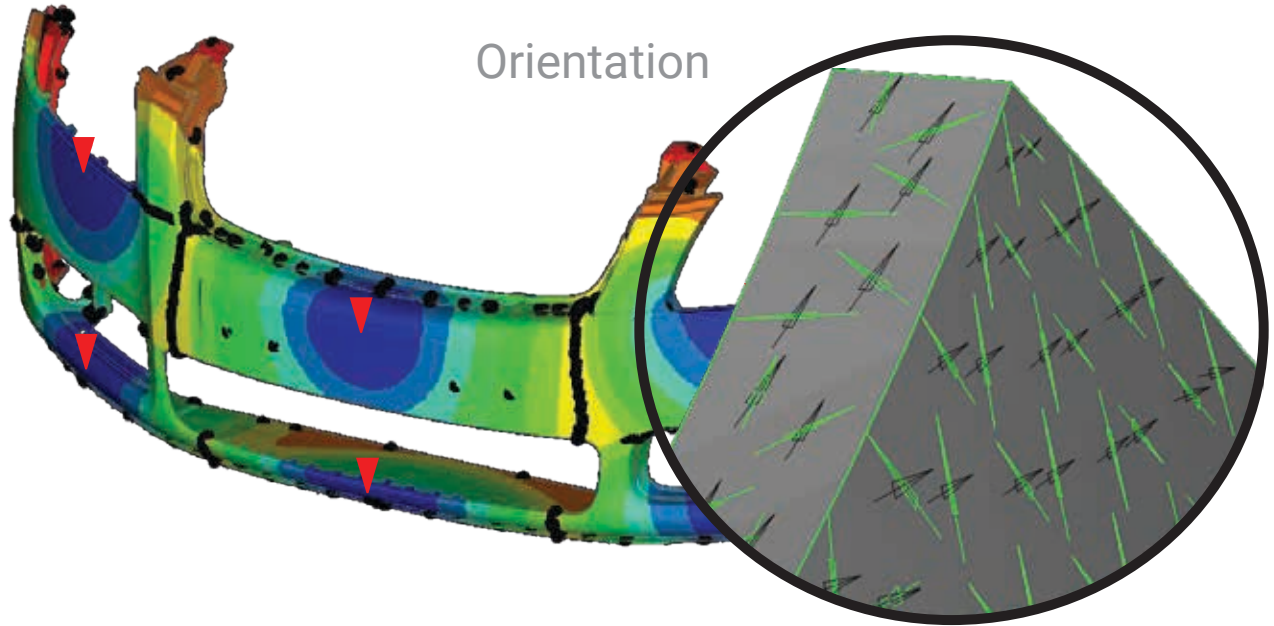
Set gates points

Run analysis

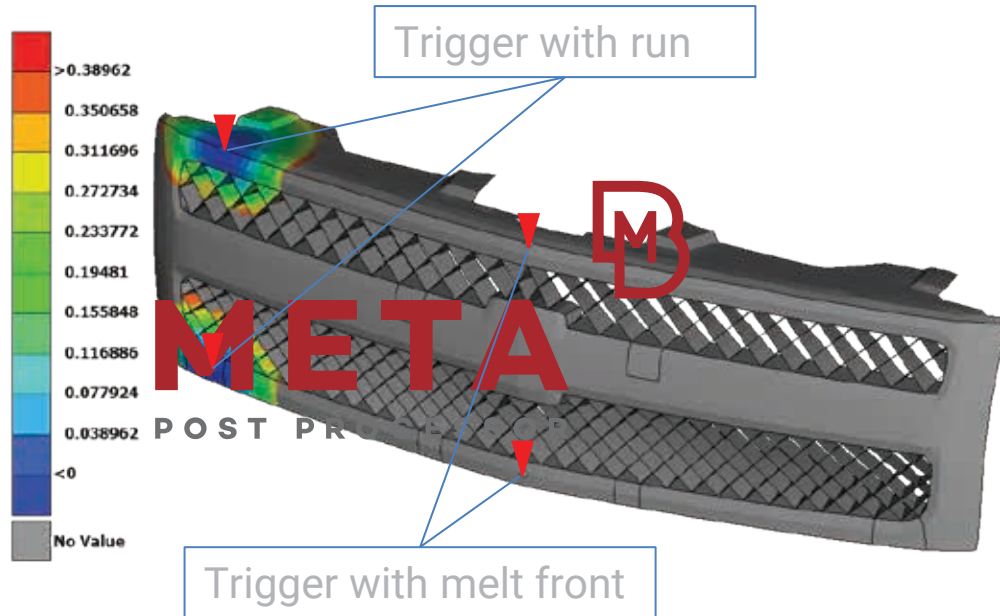
Fill time

Weld lines

Orientation

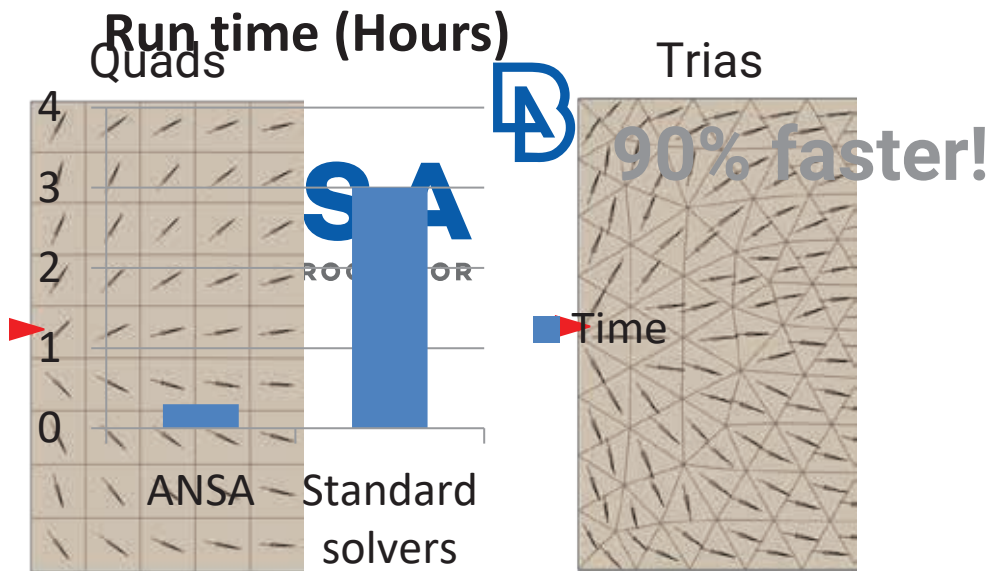


# Standard capabilities



- Control gates' triggering
- Direct post-process

# Why?

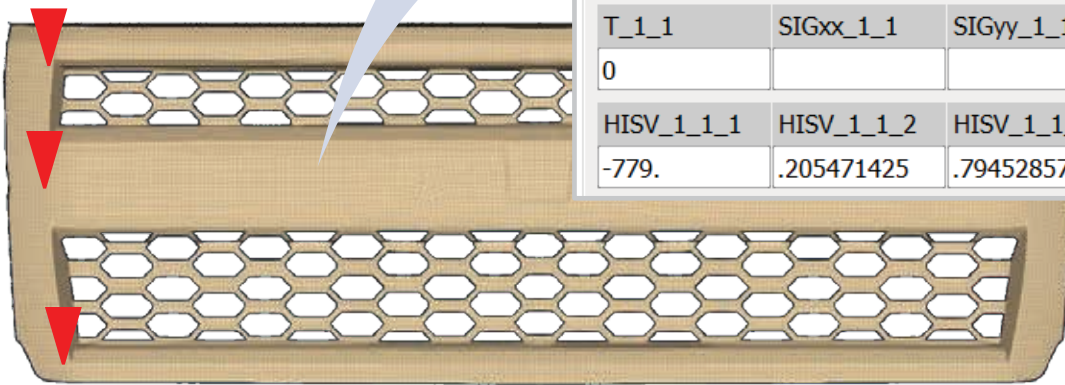


- Inside ANSA
- Free use
- On working model
- Remarkably quick

1. The CAE process
2. One-step injection molding
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# The process

Orientation tensors  
model.key  
Weld lines



MF\_GenYld  
CrachFEM

EID	NPLANE	NTHICK	NI
36045469	1	1	97
T_1_1	SIGxx_1_1	SIGyy_1_1	SI
0			
HISV_1_1_1	HISV_1_1_2	HISV_1_1_3	HI
-779.	.205471425	.794528575	0.



## External solver

Moldex3D



Run analysis



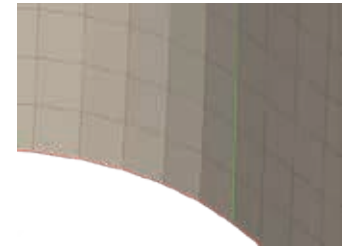
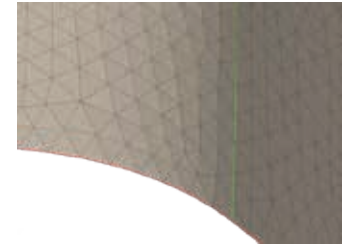
Create  
\*INITIAL\_STRESS



Export solver file



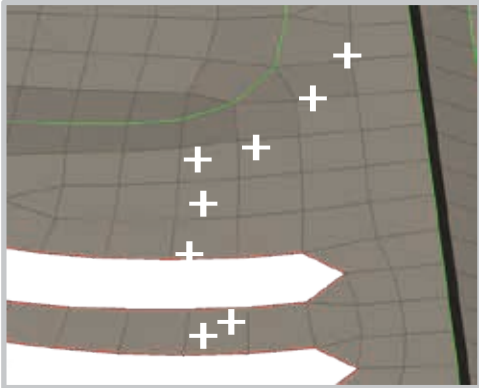
Map results



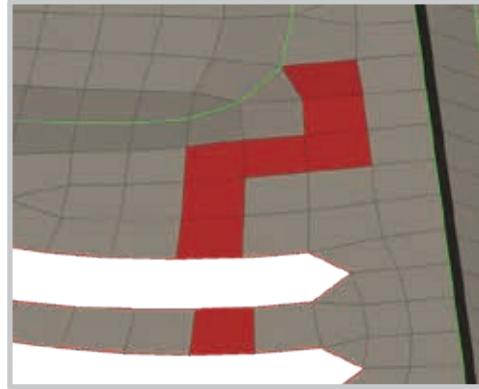


# Special tool for:

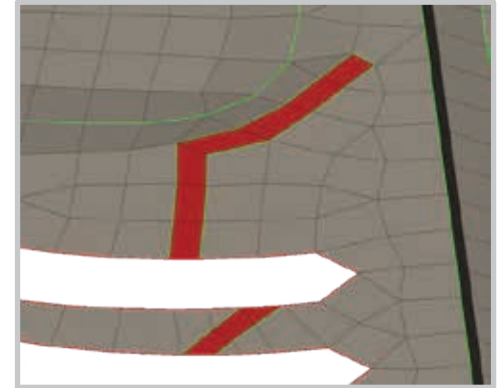
Weld lines



Transfer nodes



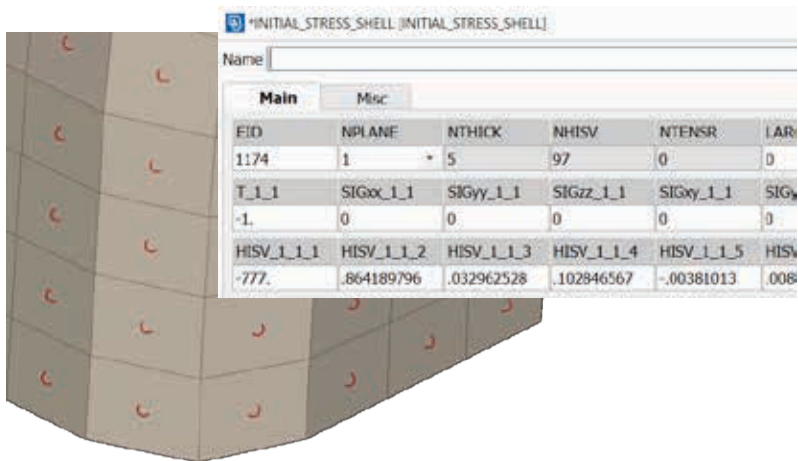
Non-destructive way



Perfect zone

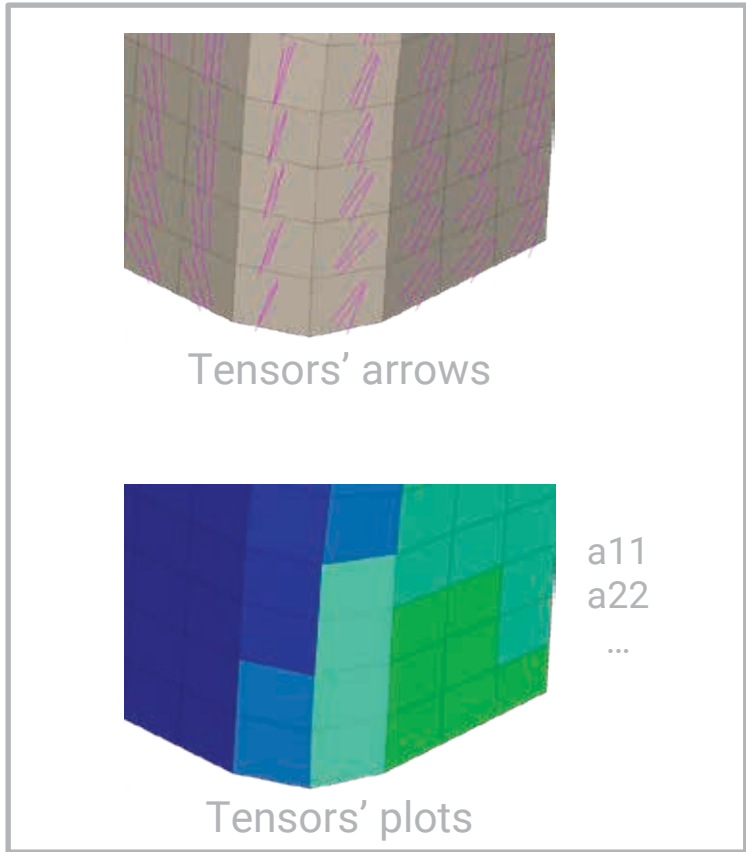
# Special tool for:

Orientation tensors

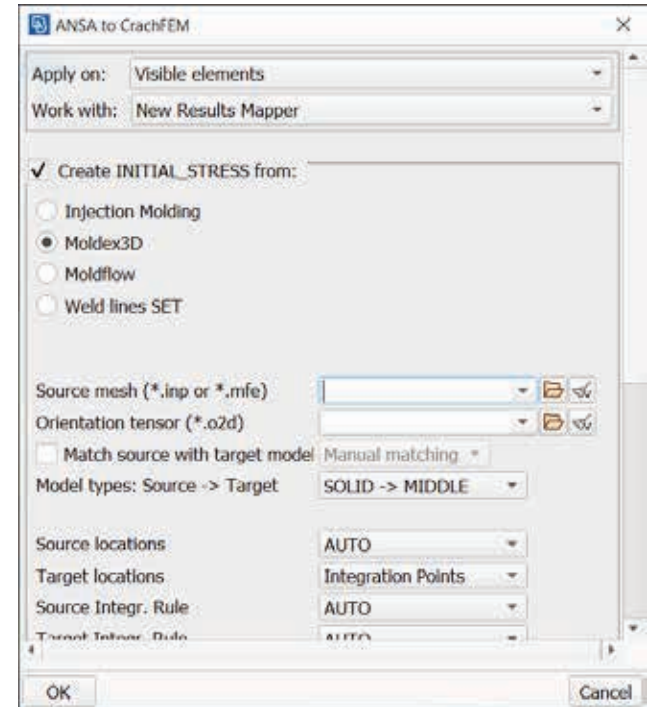
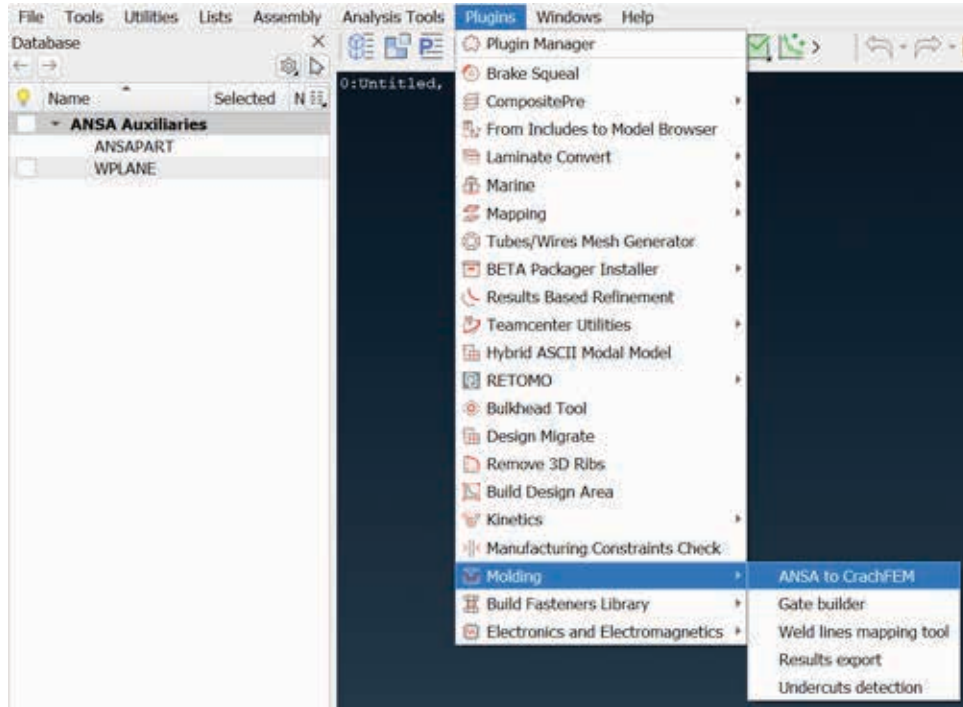


\*INITIAL\_STRESS

## Visual inspection



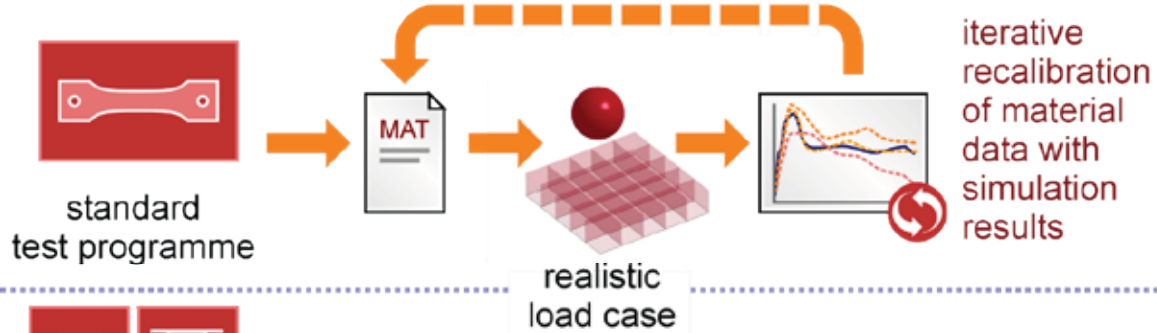
# ANSA to CrachFEM interface



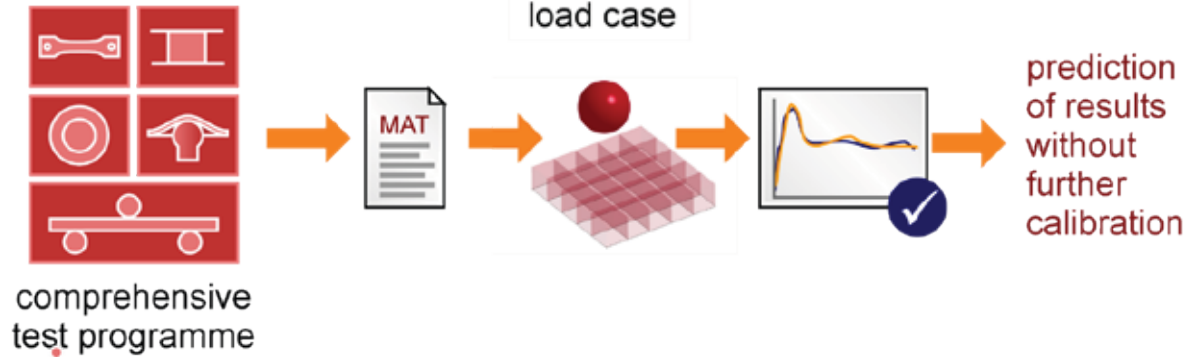
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# Predictive

„classic“  
approach



MF GenYld  
+  
CrachFEM



# One material model – many applications



UHSS



Thermoplastic



LPDC



Al or Mn  
extrusions



Elastomer



Plywood



AM Metals



Fabric



Glass



SFRT



UD



HPDC



Mild steel



AM Polymers



Orthotropic Elasticity



Orthotropic yield locus



Yield locus correction



Ductile normal fracture



Ductile shear fracture



Tensile instability



Brittle fracture



Orthotropy of fracture



Post-critical failure



Evolution of porosity



Local initialization



Stochastic scatter



Composite scatter



Interpolation

# One material model – SFRT



SFRT



Orthotropic Elasticity



Yield locus correction



Orthotropic yield locus



Ductile normal fracture



Ductile shear fracture



Tensile instability



Brittle fracture



Orthotropy of fracture



Post-critical failure



Evolution of porosity



Local initialization



Stochastic scatter

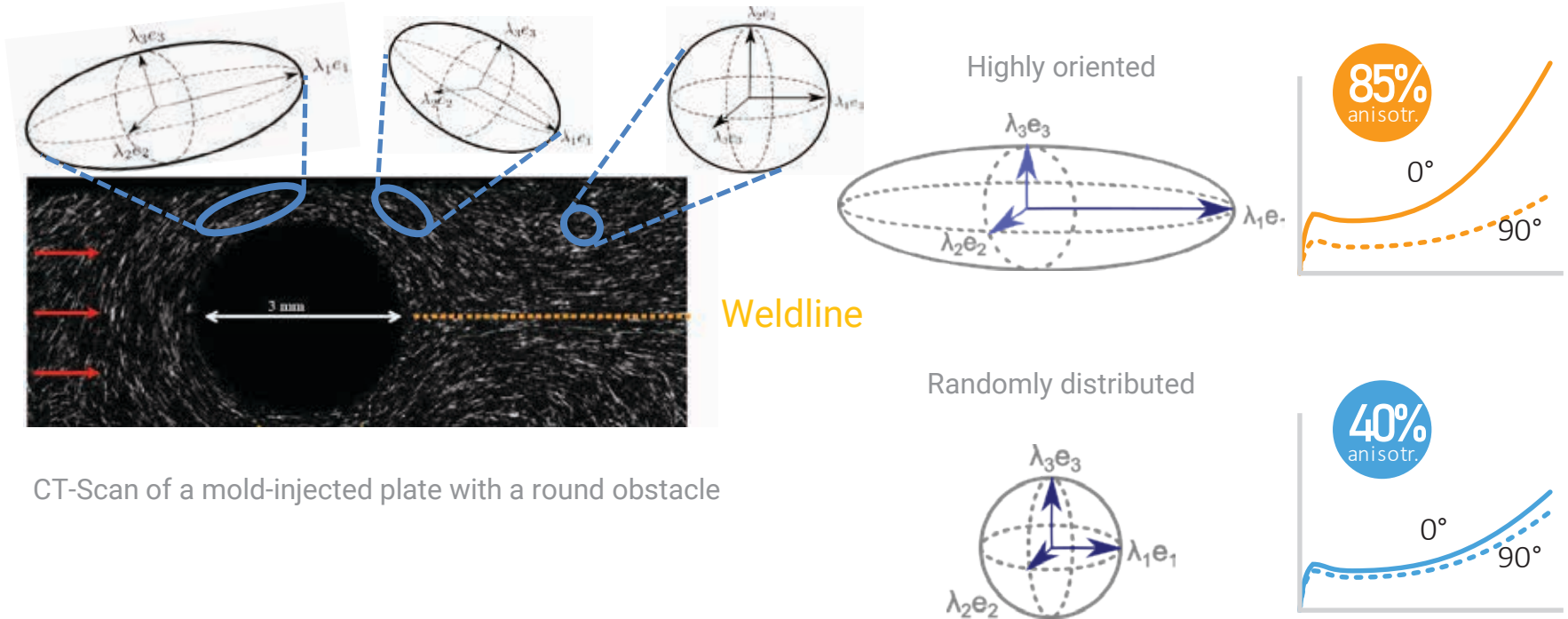


Composite modeling



Interpolation

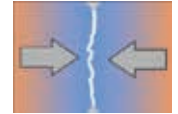
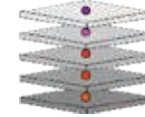
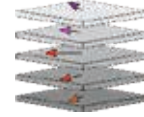
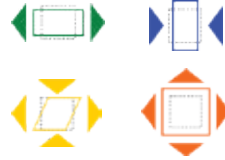
# One material model – many applications



CT-Scan of a mold-injected plate with a round obstacle



# Fiber distribution



Level of detail



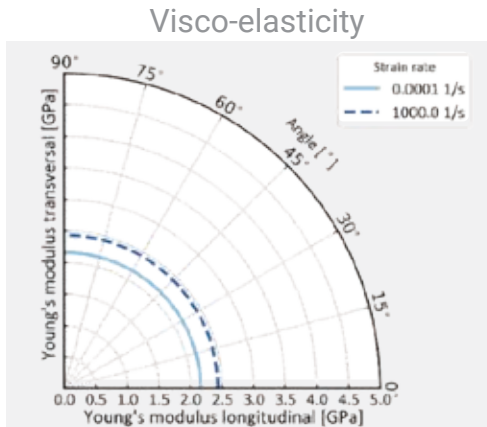
Material model	Experimental Cost	Anisotropic hardening	Mapping		
			Fiber orientation	Degree of anisotropy	Weldlines
vonMises isotropic	Elevated	No	No	No	No
CrachFEM isotropic	↑ - ↑	Yes	No	No	Yes
CrachFEM orthotropic	↑ High ↑	Yes	Yes*	Yes	Yes

# Material card for PA6-GF30

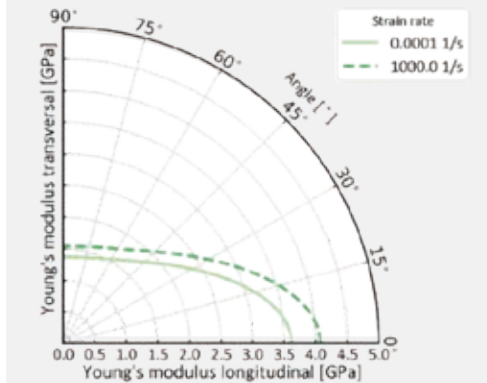


Interpolating

Isotropic

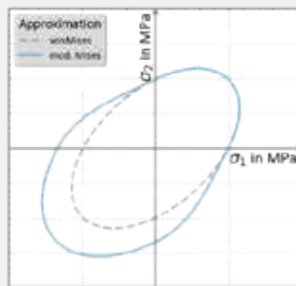


Orthotropic

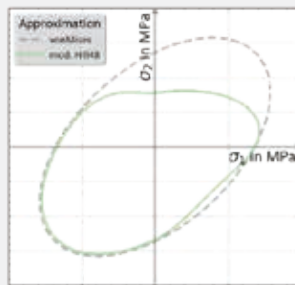


Yield locus

mod. vonMises

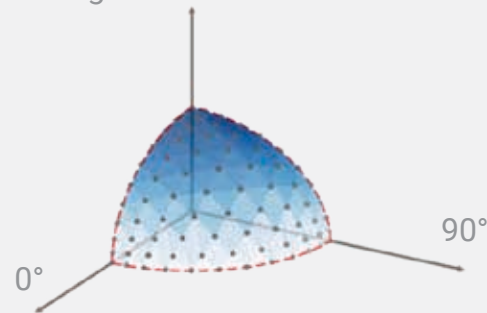


mod. Hill48

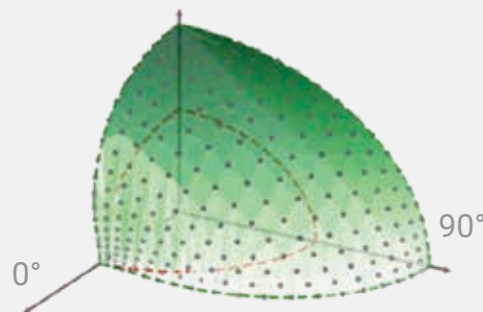


Fracture orthotropy

Triangulated fracture surface



Red unit circle = isotropy



# CrachFEM-modules for SFRT

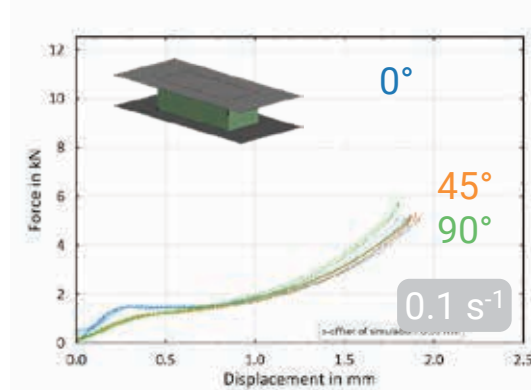
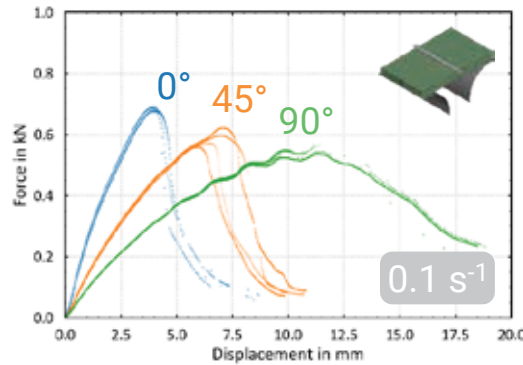
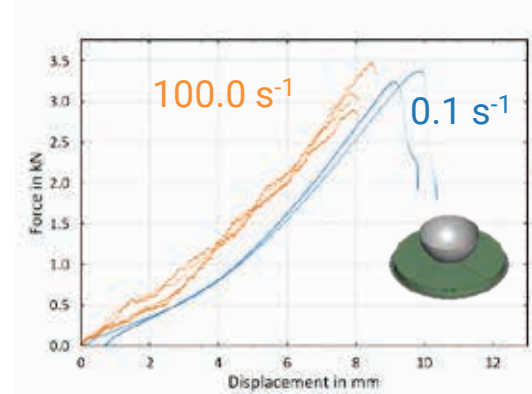
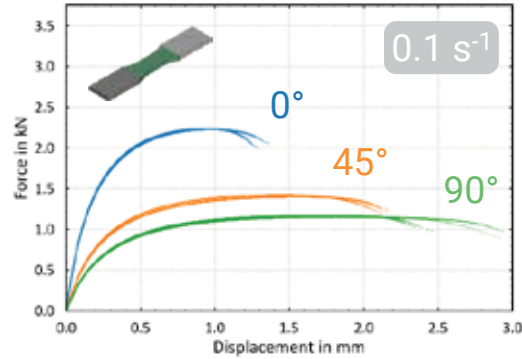
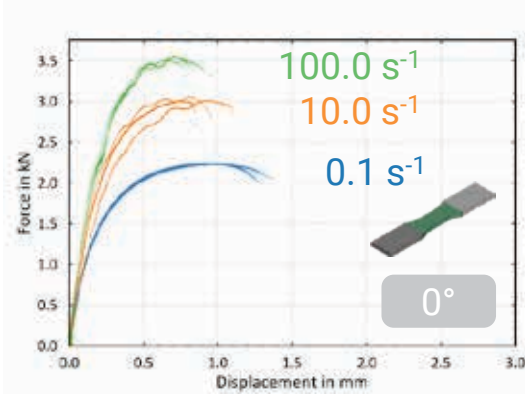
	elastic behaviour	plastic behaviour	stress-space anisotropy	com- pressibility	normal fracture	shear fracture	brittle fracture	tensile instability
isotropic								
orthotropic								
generally anisotropic								
strain-rate dependent								
strain dependent								



Interpolating  
Material card



# Coupon level

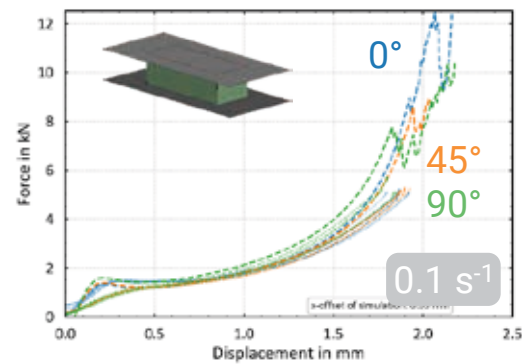
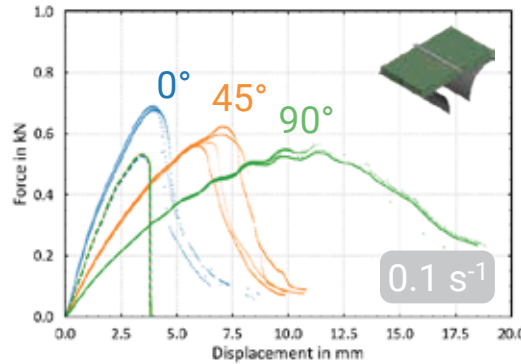
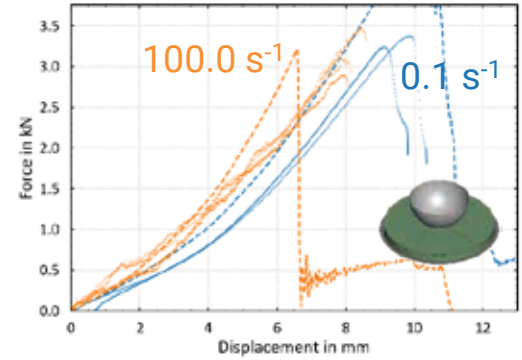
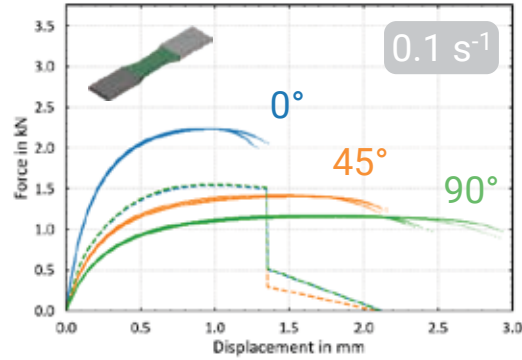
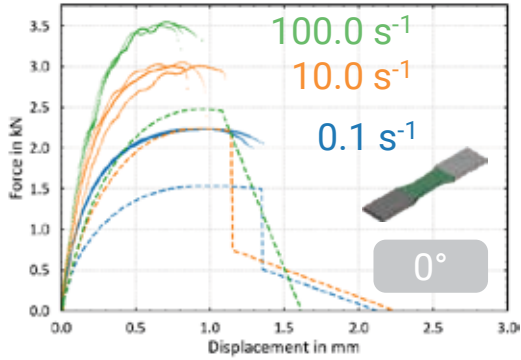


PA6-GF30  
material

By courtesy  
of ShareFEA

# Coupon level

Isotropic

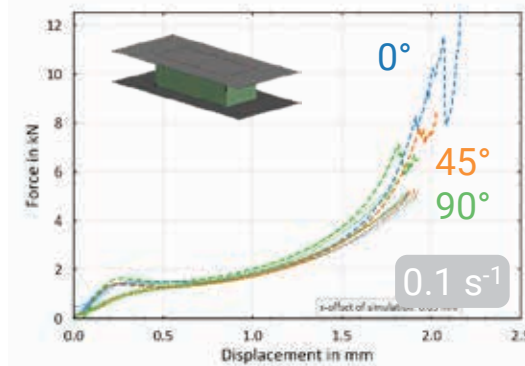
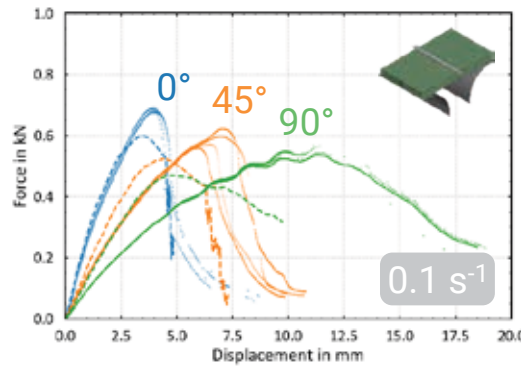
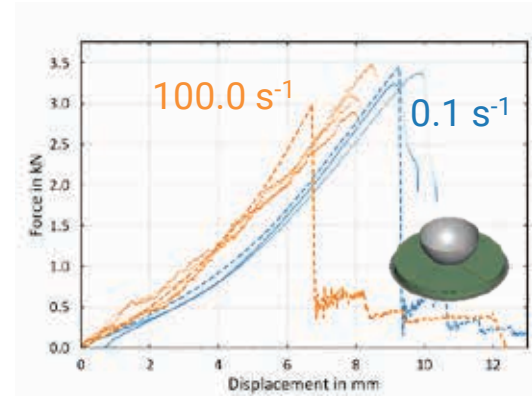
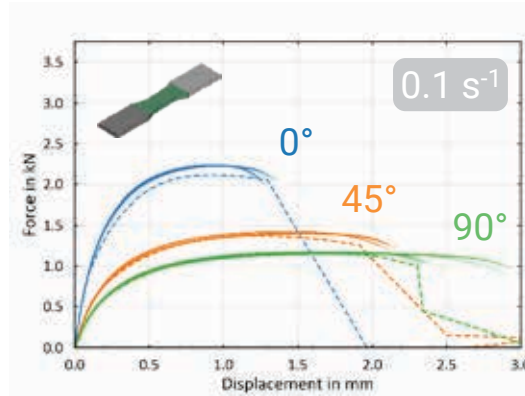
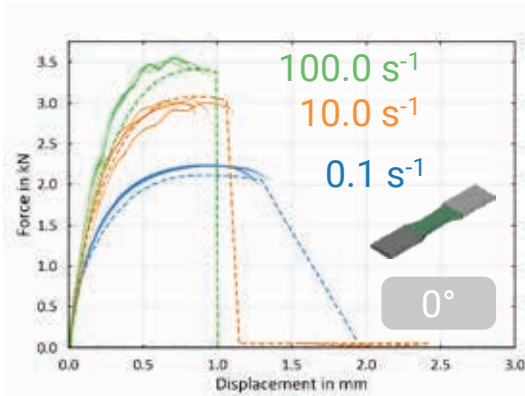


PA6-GF30 material

By courtesy of ShareFEA



# Coupon level

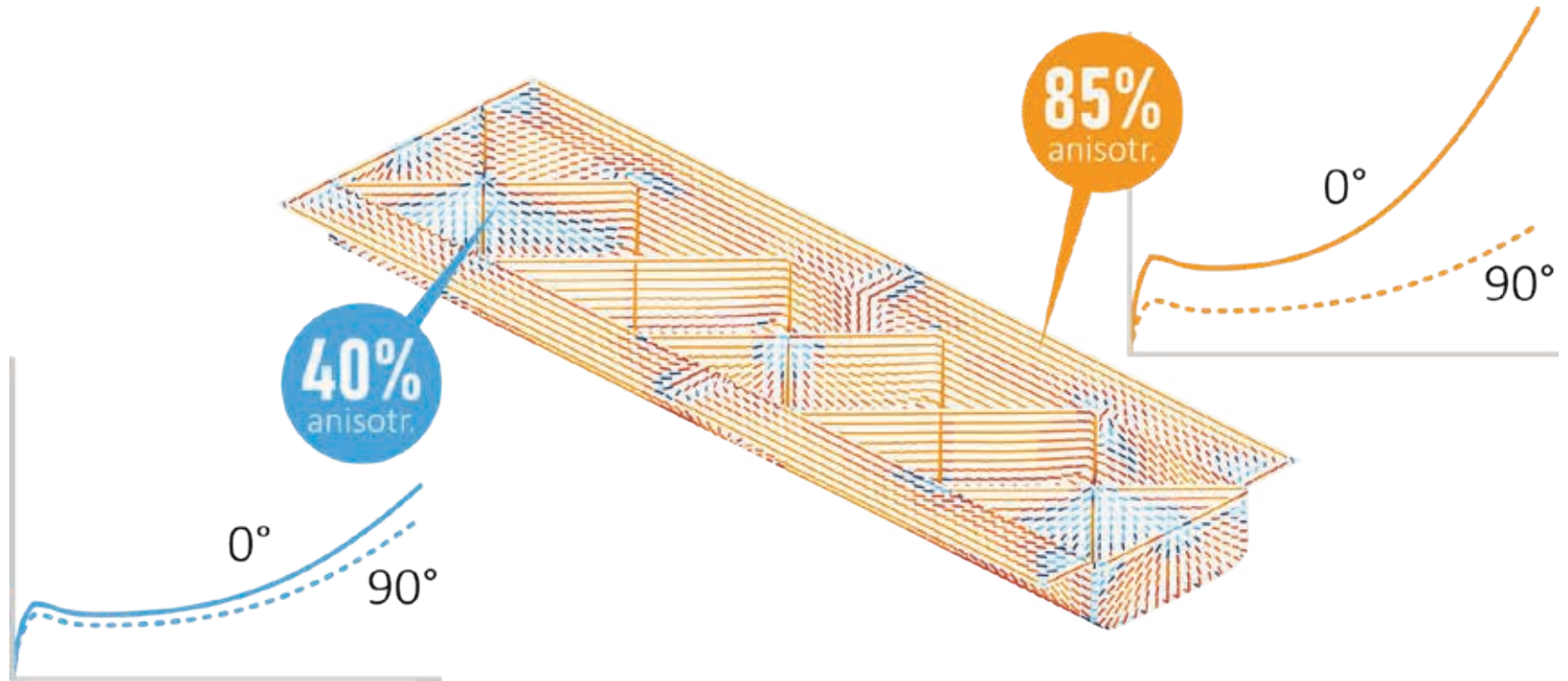


PA6-GF30  
material

By courtesy  
of ShareFEA

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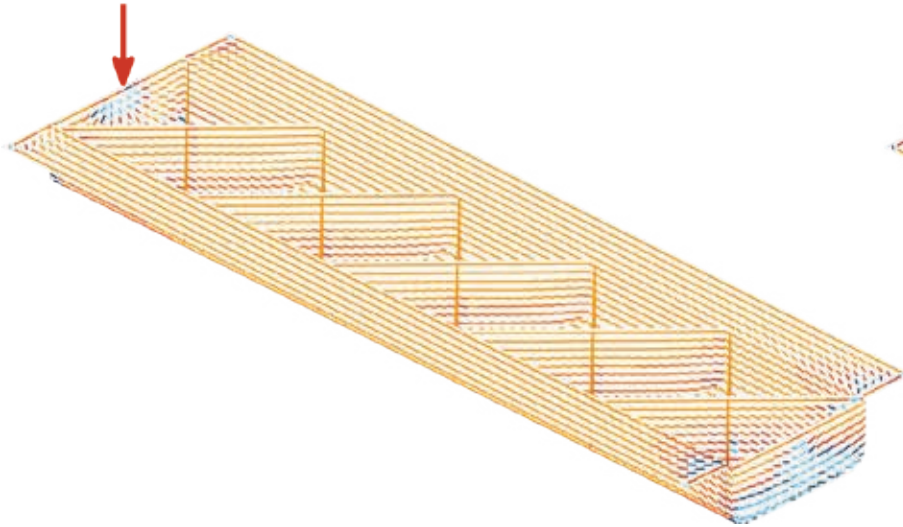
## Generic hat profile





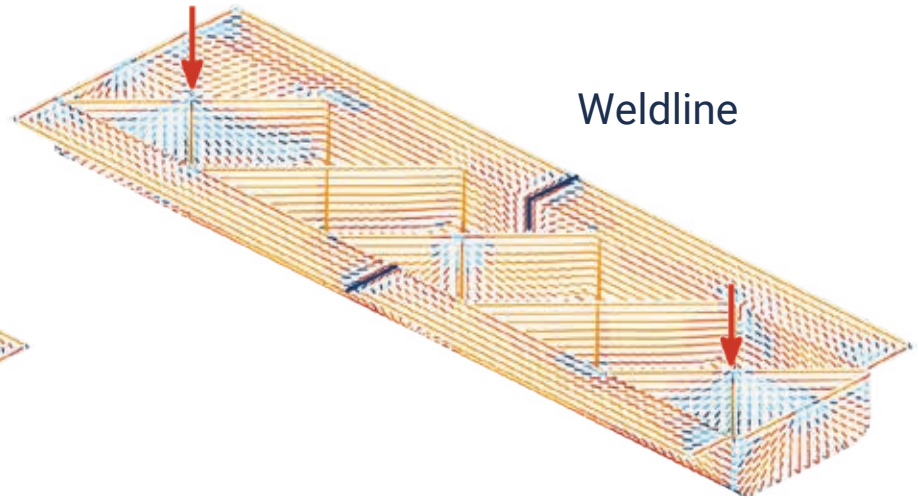
# Injection molding

1



1 nozzle at the front side

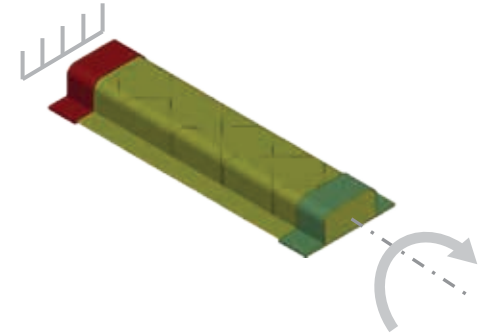
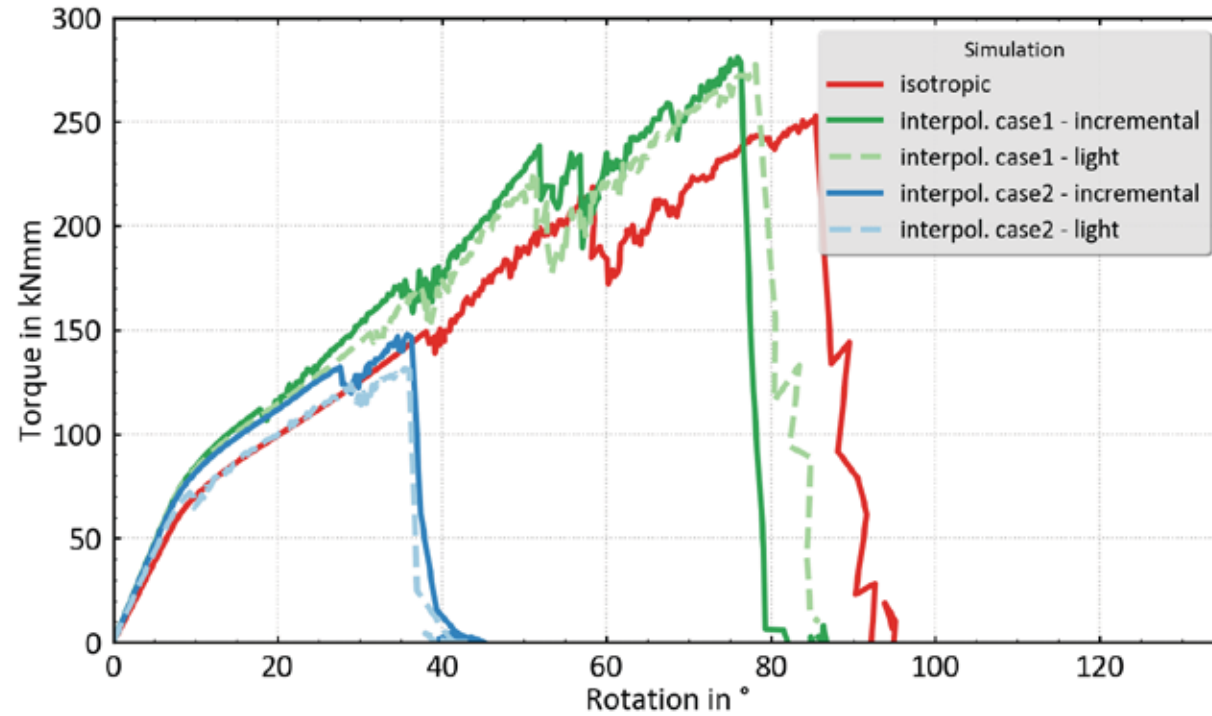
2



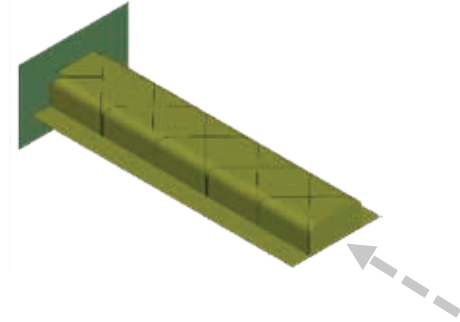
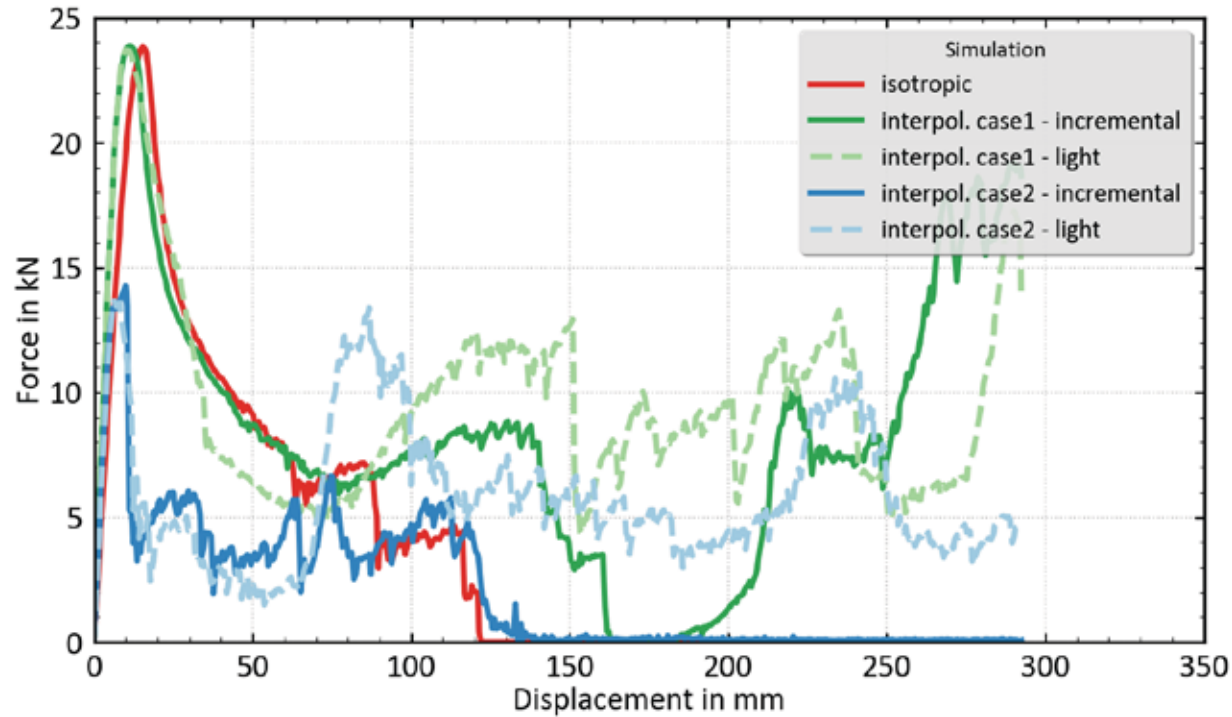
Weldline

2 nozzles

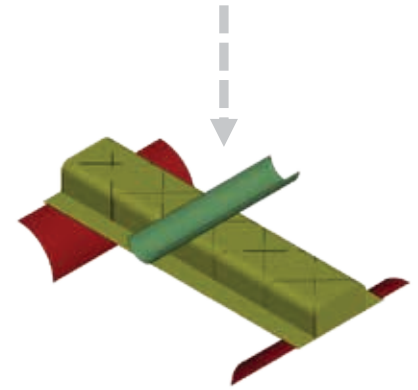
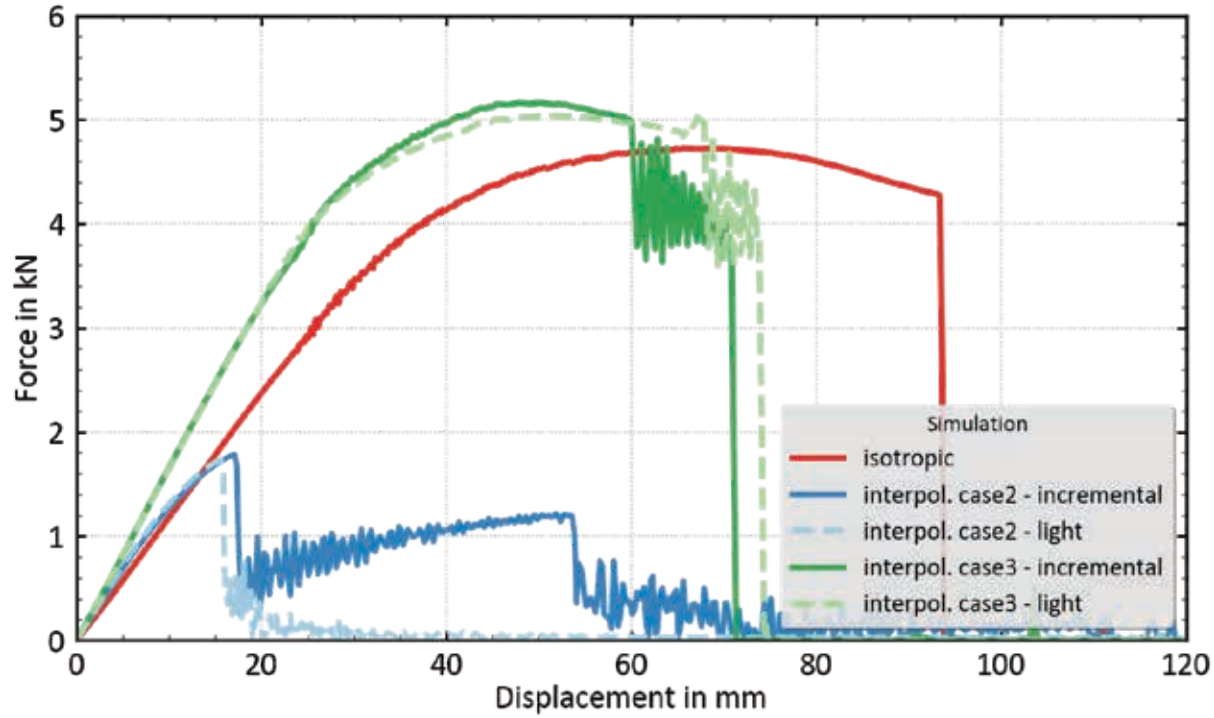
# Axial torsion



# Axial crushing



# 3-point bending



# Conclusions

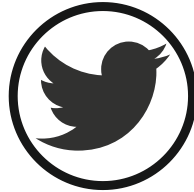
Minimum resources for part improvement in pre-mature stage

Easy pre-processing of the results using the dedicated tools

Advanced solutions for connecting ANSA with external solvers

Robust simulation integrating the manufacturing influence

High accuracy using modular CrachFEM material model



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