

# Spritzgieß- und Strukturmechaniksimulation vereint Eine Story

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# AGENDA

- INTRODUCTION
- AUTODESK MOLDFLOW
  - MOTIVATION
  - CASE STUDY
- AUTODESK HELIUS
  - MOTIVATION
  - CASE STUDY
  - SIMULATION STRATEGIES / COMPARISON
- WORKFLOW

# INTRODUCTION



## Software Reseller



- Since 12 years
- More than 400 customers



## Simulation Service Provider



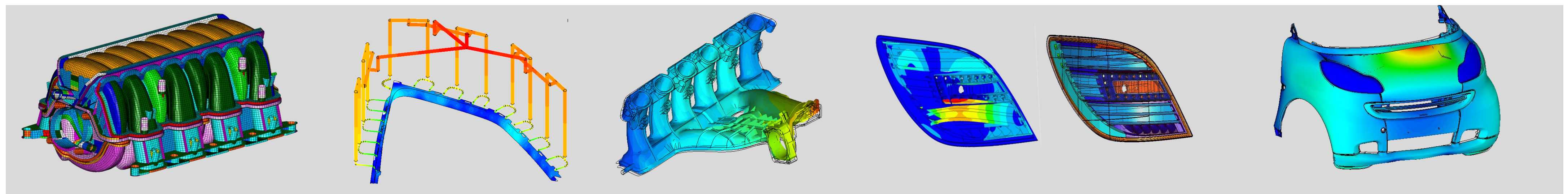
- Since 32 years
- More than 17.000 successful projects



# MOTIVATION

Due to systematic use of simulations our customers generally achieve

- shorter development times
  - reduced development and production costs
  - increased part and mold quality
- elaborate advantages to competitors



# MOTIVATION

## Autodesk Moldflow

How do we achieve these obligations?

Development process



Part Design



Tool Design



Production

Cost  
Responsibility

Influence  
Time

# MOTIVATION

## Autodesk Moldflow

How do we achieve these obligations?



Part Design

- Simulation phase S1
- Part geometry
  - Material
  - Injection locations
  - Process settings



Tool Design

- Simulation phase S2
- Tool influences
  - Gating system
  - Cooling system
  - Process settings
  - Tool materials



Production

- Simulation phase S3
- Process optimization after first shots
  - Optimization of running processes
  - Gain in knowledge due to understanding of interactions



# MOTIVATION

## Autodesk Moldflow

How do we achieve these obligations?

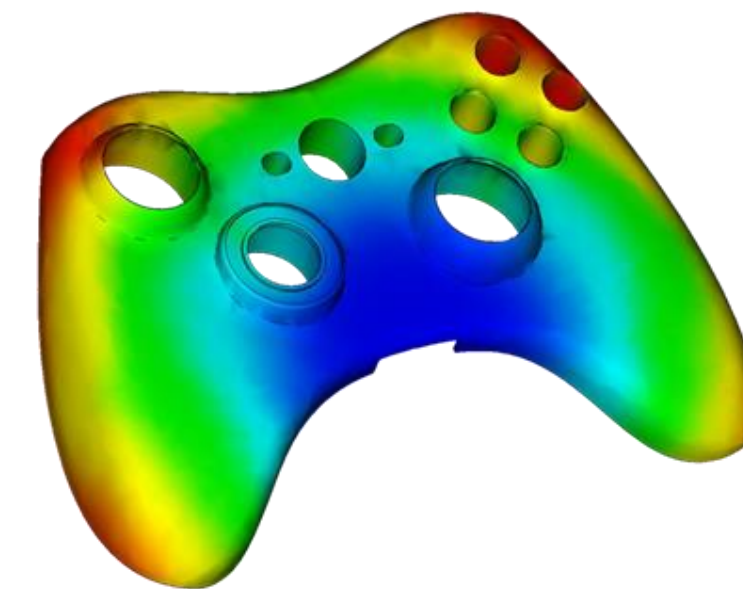
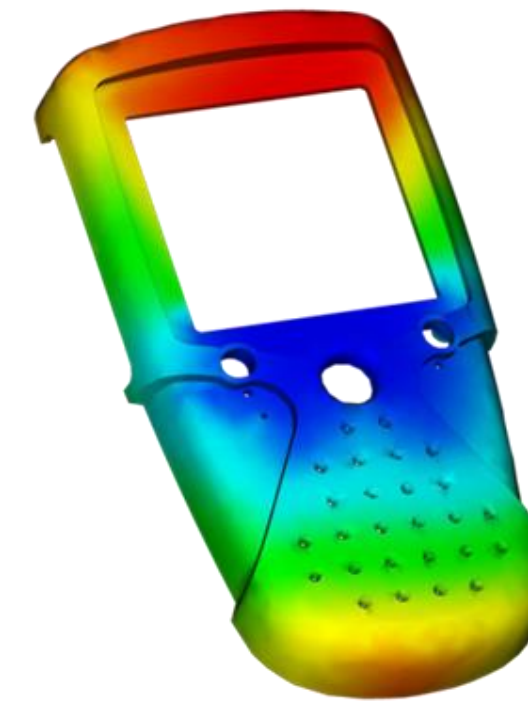


Part Design

**Is the molded part designed for plastic?**

- General fillability / process reliability
- Weld lines / air traps
- Optimization of injection locations
- Melt balancing / achieving a minimum amount of pressure
- Optimization of wall thickness differences
- Shrinkage and warpage predictions
- Etc.

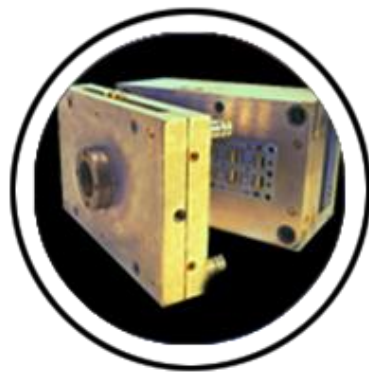
→ Transfer of a mature design to the tool shop



# MOTIVATION

## Autodesk Moldflow

How do we achieve these obligations?

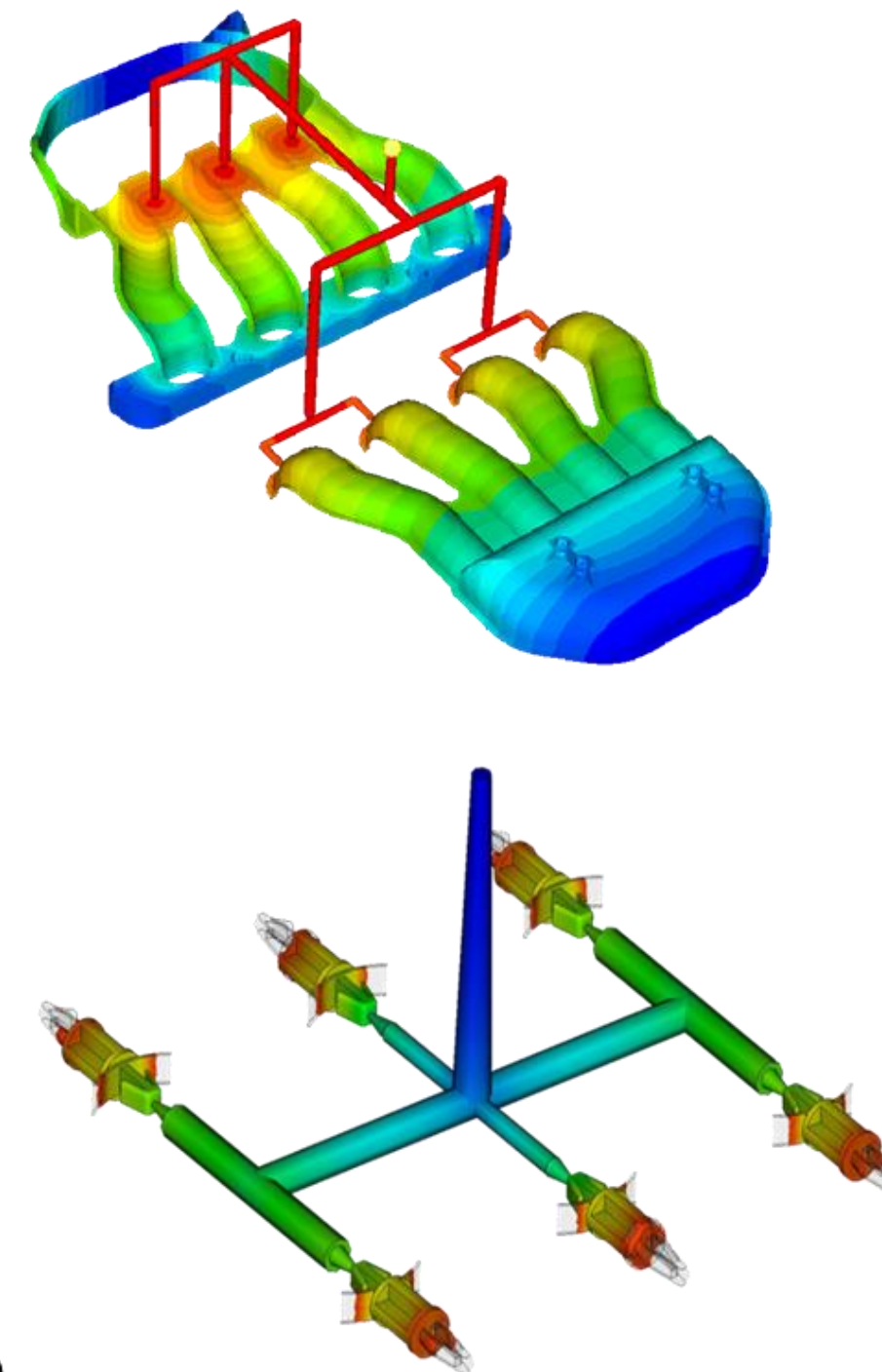


Tool Design

### Rheology & Thermodynamics of the mold?

- Optimization of the sealing point
- Balancing of the runner system
- Cascade / Sequential filling control
- Optimization of the cooling system (Cycle time, Quality)
- Necessity of inserts
- Shrinkage and deformation behaviour

- Saving of change loops
- Elimination of possible errors during production





# MOTIVATION

## Autodesk Moldflow

How do we achieve these obligations?



Production

### Can production costs be reduced?

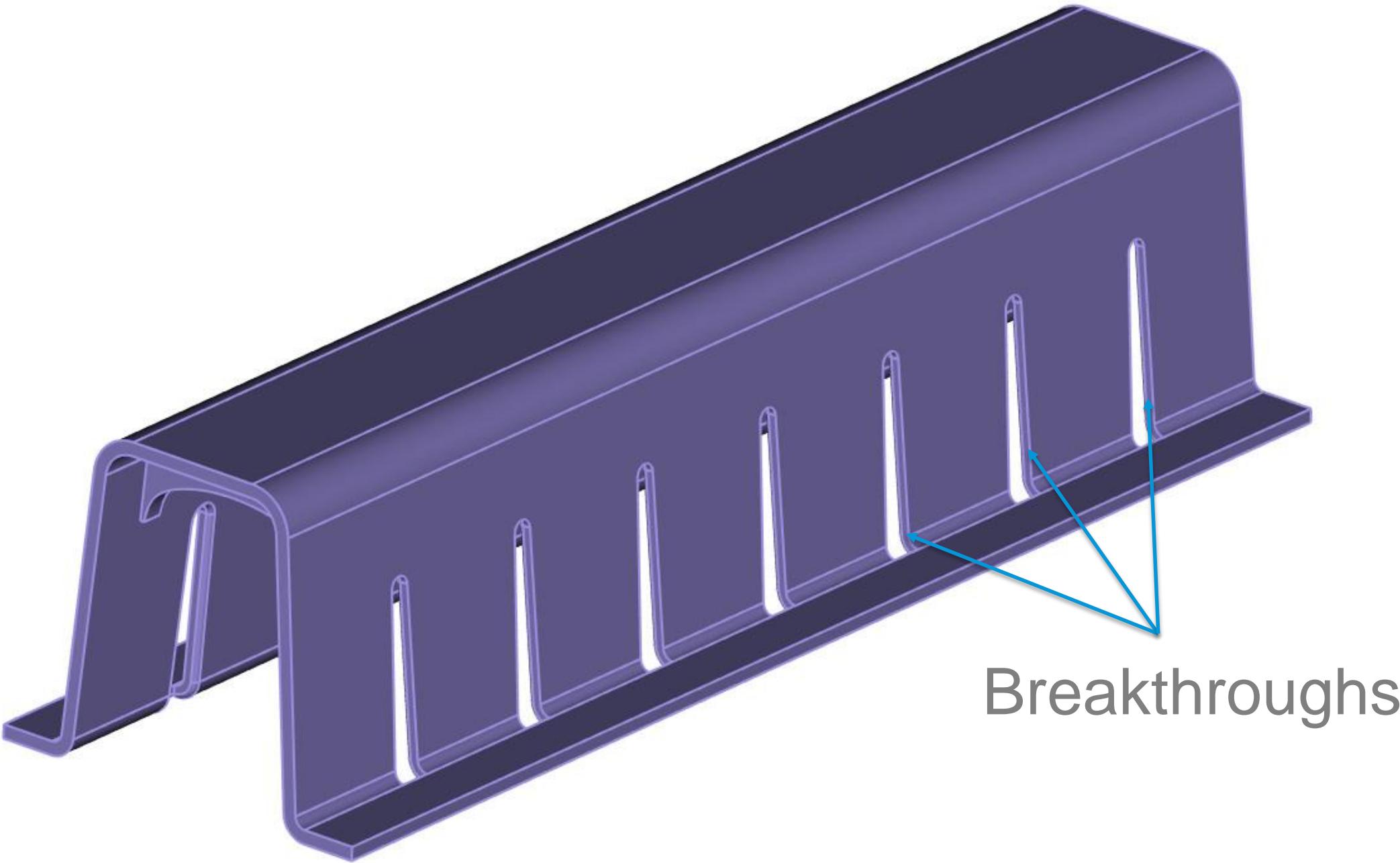
- Material → according to requirement / specification sheet ❌
- Weight → is determined by molded part design ❌
- Cycle time → is based on the wall thickness distribution ❌  
→ is determined by the cooling concept ❌
- Tool cost → is determined by the part complexity ❌
- Machine size → thin parts require a higher amount of filling pressure ❌

→ Optimal utilization of savings potentials only possible through early, design accompanying simulation

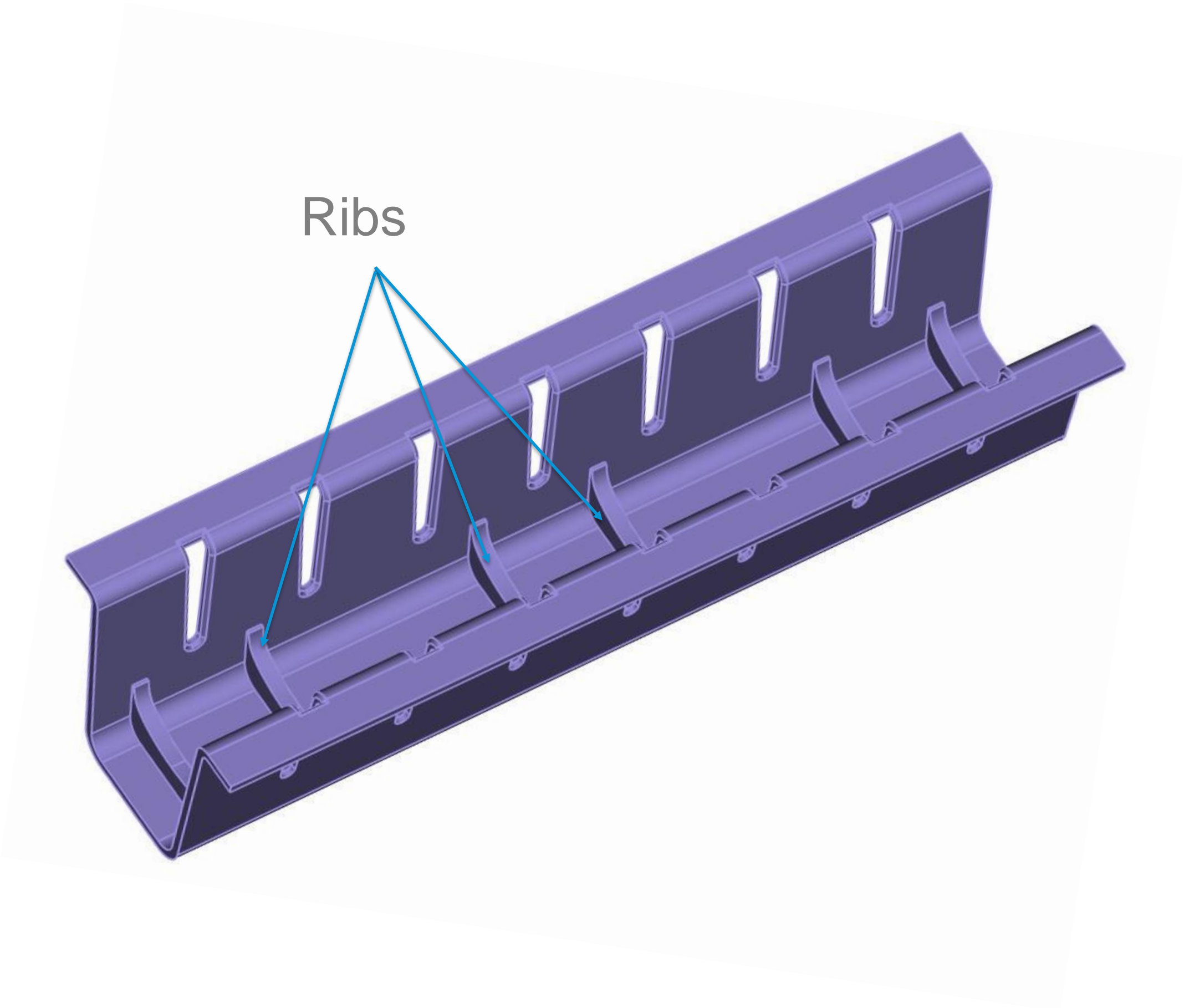
# CASE STUDY

## Part Overview

Top side



Bottom side

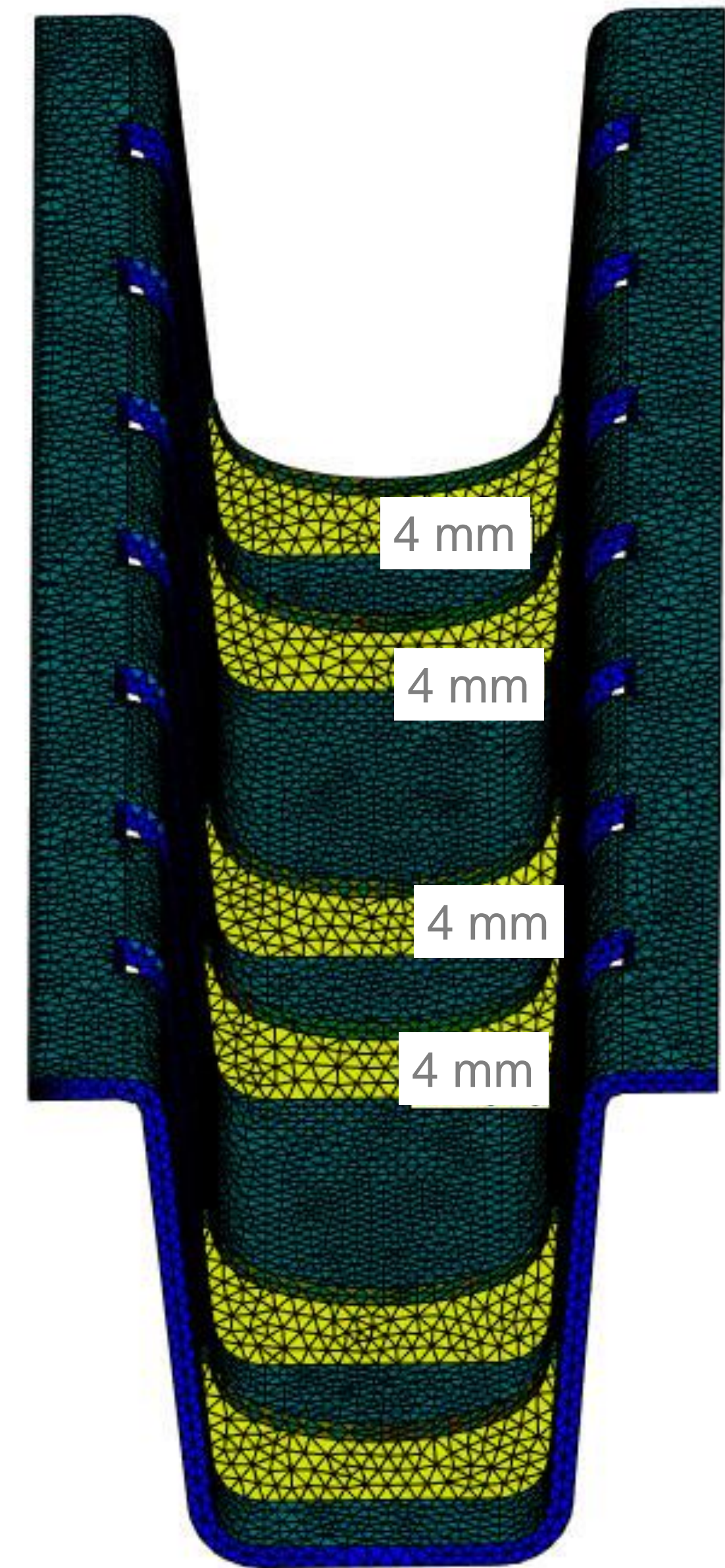
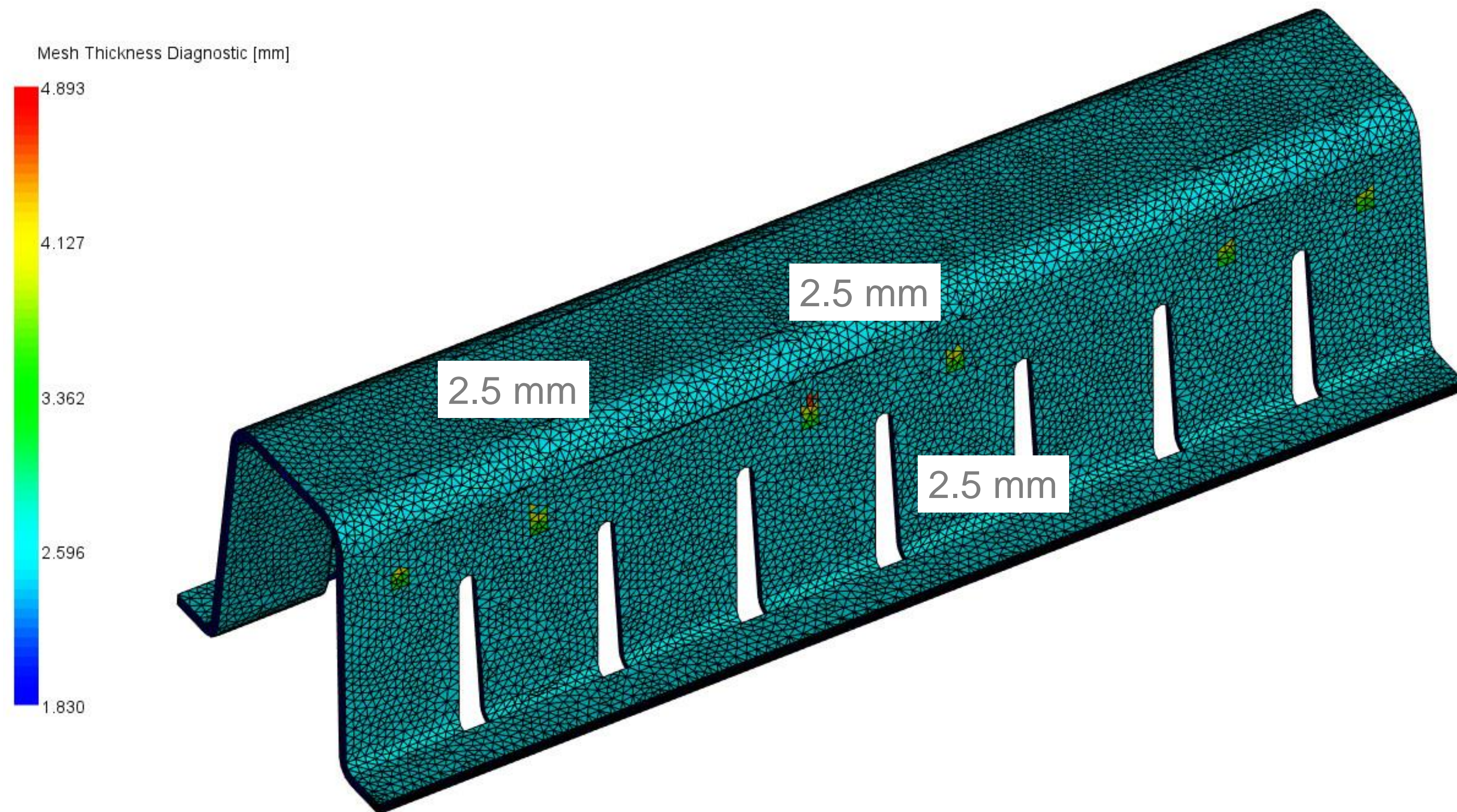




# CASE STUDY

## Thickness Overview

- The main wall thickness is 2.5 mm
- The ribs on the bottom side are 4 mm





# CASE STUDY

## Material Overview

- The material is a Polypropylene by Basell
- Polypropylenes are crystalline polymers
- It is 30 % glass fiber filled
  - Due to the glass fibers the Elastic Moduli vary from 1st principal direction to 2nd principal direction

Mechanical properties data		
Elastic modulus, 1st principal direction (E1)	4890	MPa
Elastic modulus, 2nd principal direction (E2)	3210	MPa

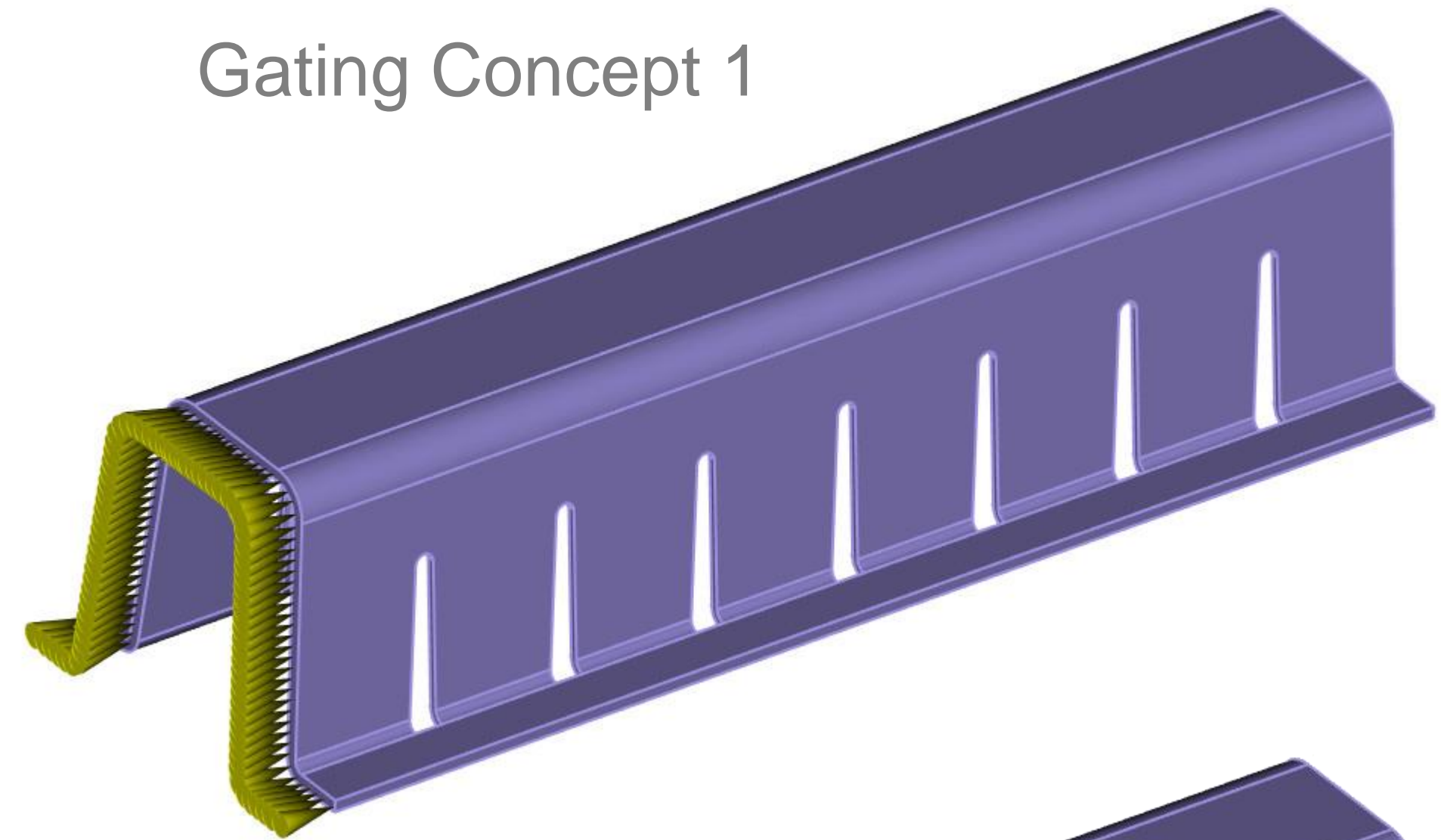


# CASE STUDY

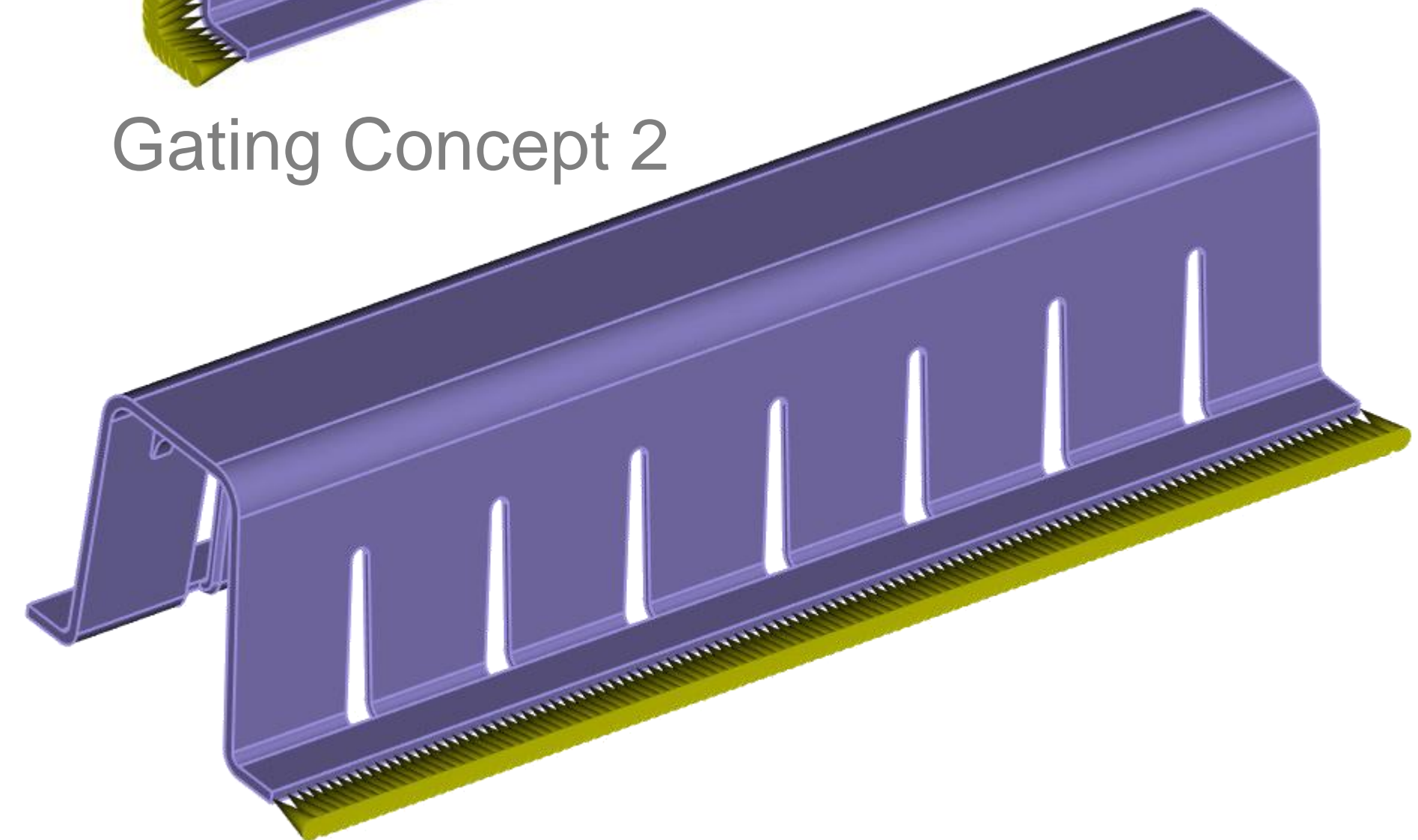
## Gating concepts

- **1st gating concept is longitudinal**
  - Weld lines form on the side of the part
  - Fill time is slightly longer due to a longer flow path
- **2nd gating concept is crosswise**
  - Weld lines form on top of the part
  - Fill time is slightly shorter than on gating concept 2

Gating Concept 1



Gating Concept 2

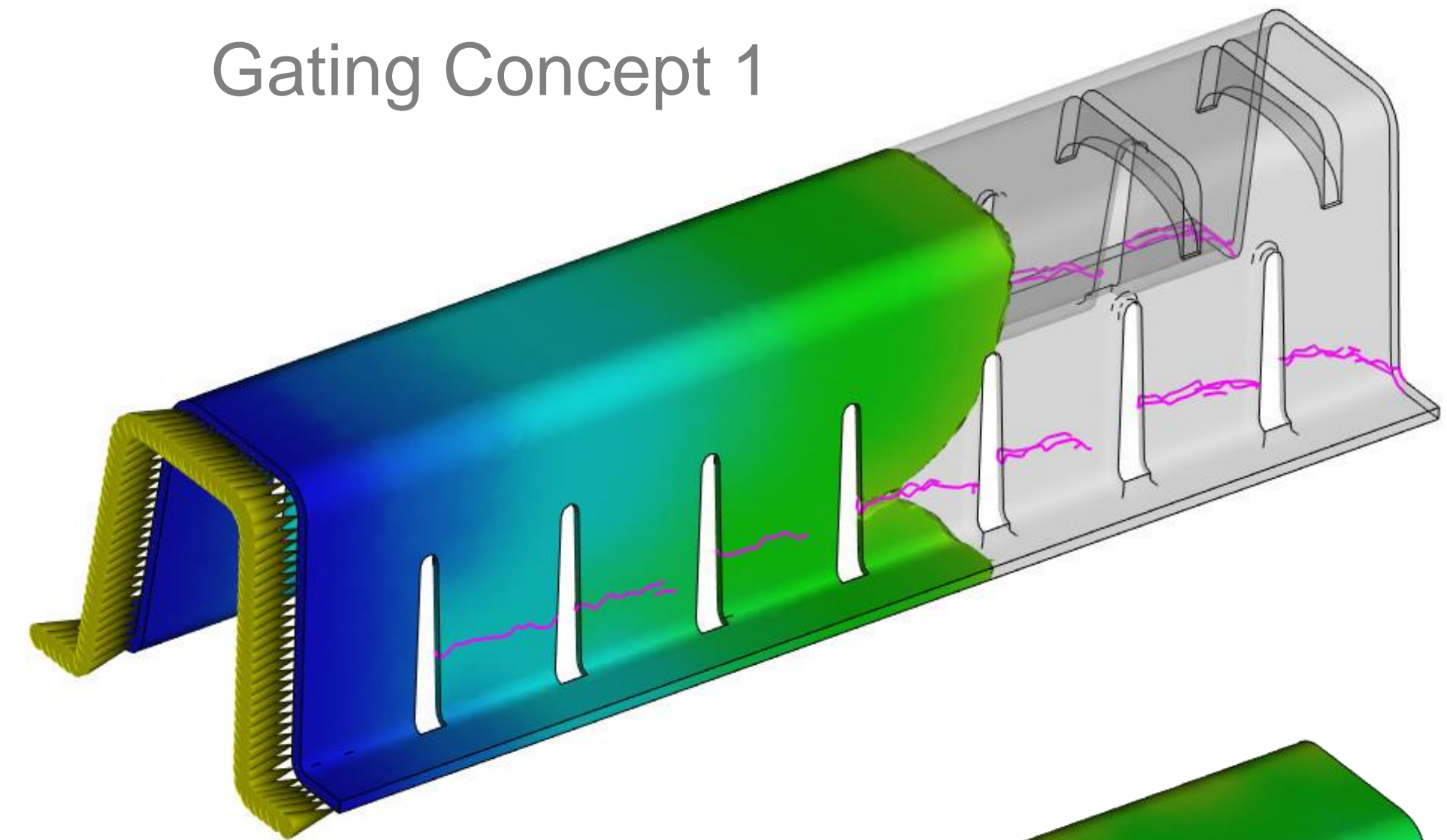


# CASE STUDY

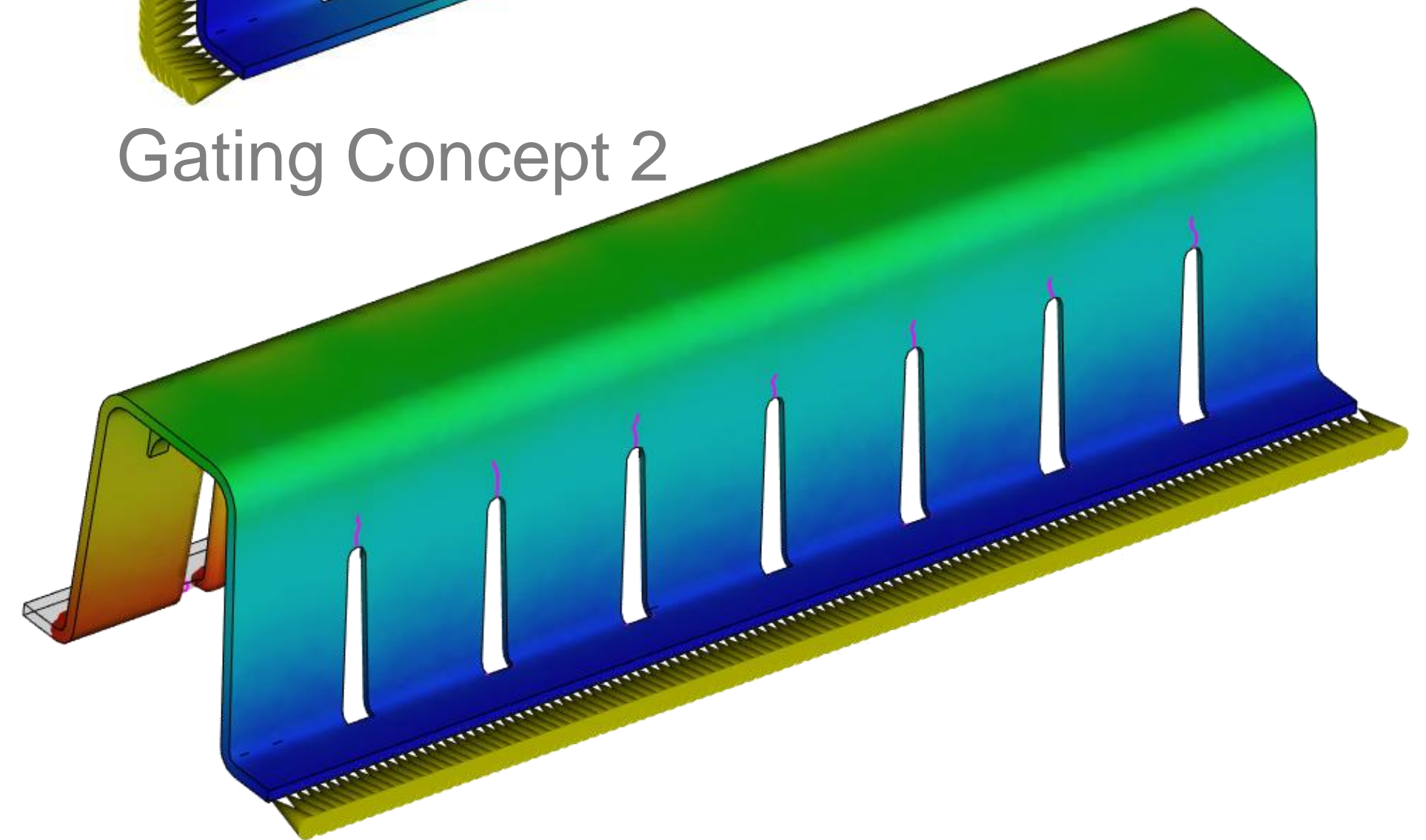
## Fill (Weld lines)

- Both gating concepts lead to a complete filling
- Behind the breakthroughs on the part weld lines are being formed on the part
- Weld lines may lead to mechanical weak points
  - It is important to determine which positioning and therefore which gating concept leads to the least weakening weld line formations

Gating Concept 1



Gating Concept 2

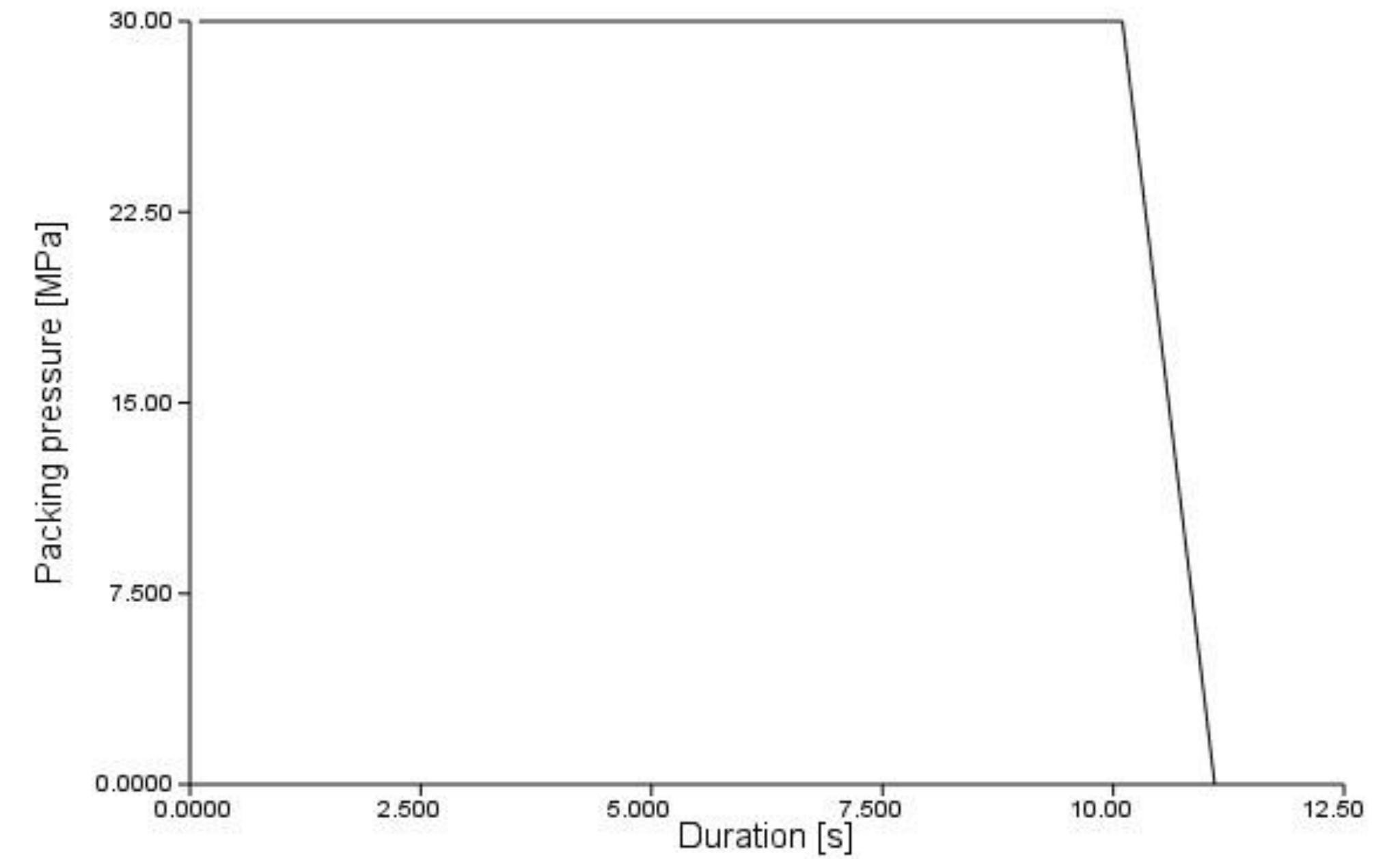




# CASE STUDY

## Packing Pressure

- For the packing pressure studies we stick to gating concept 1
- Initial process settings for the part determined a packing pressure time of 11 seconds on 300 bar

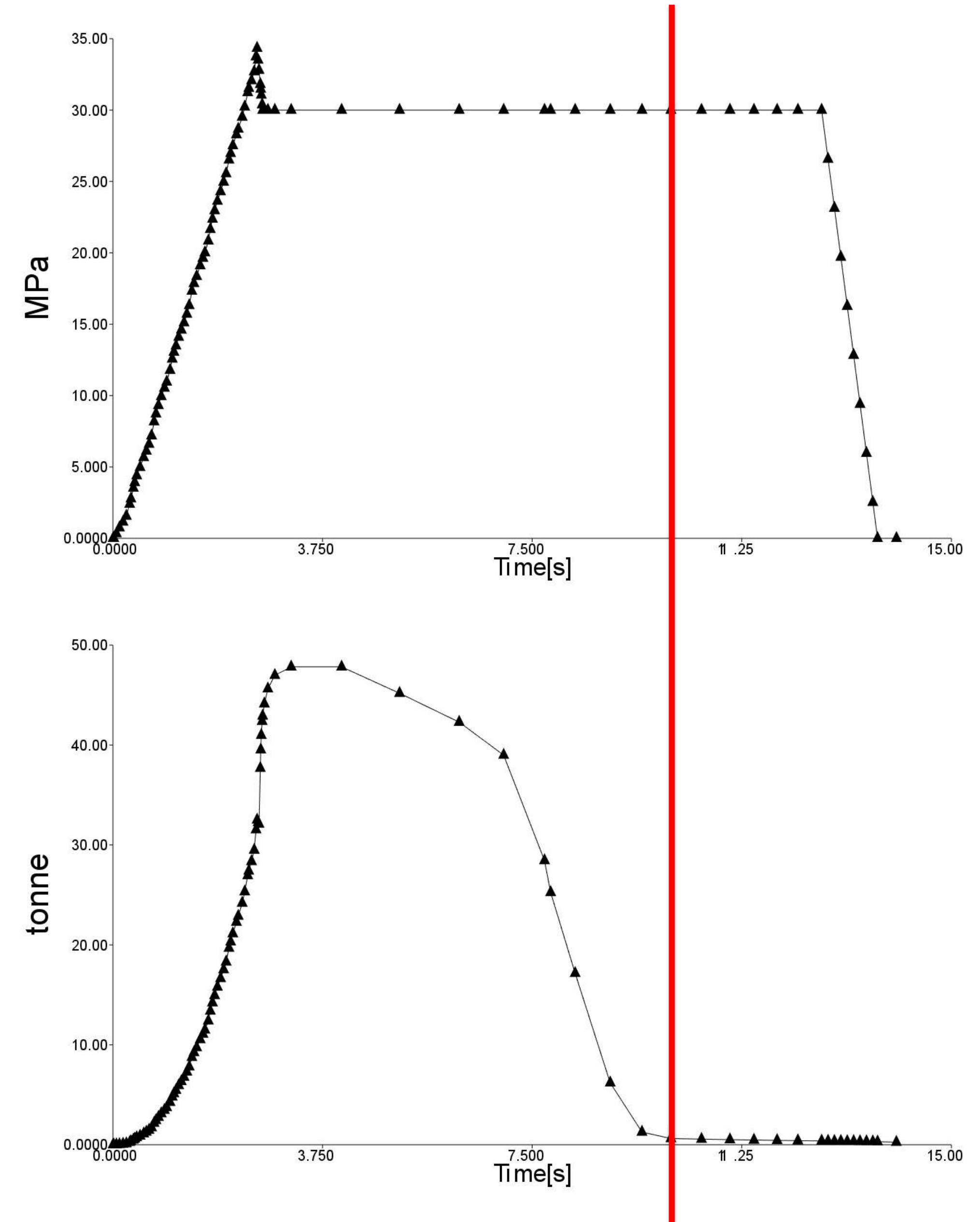


# CASE STUDY

## Packing Pressure

- When comparing the pressure and clamp force curves the clamp force drops to 0 very early
- At the same time the packing pressure is still active
- The packing pressure can be reduced to around 7 seconds

→ This leads to a time reduction of around 40 %

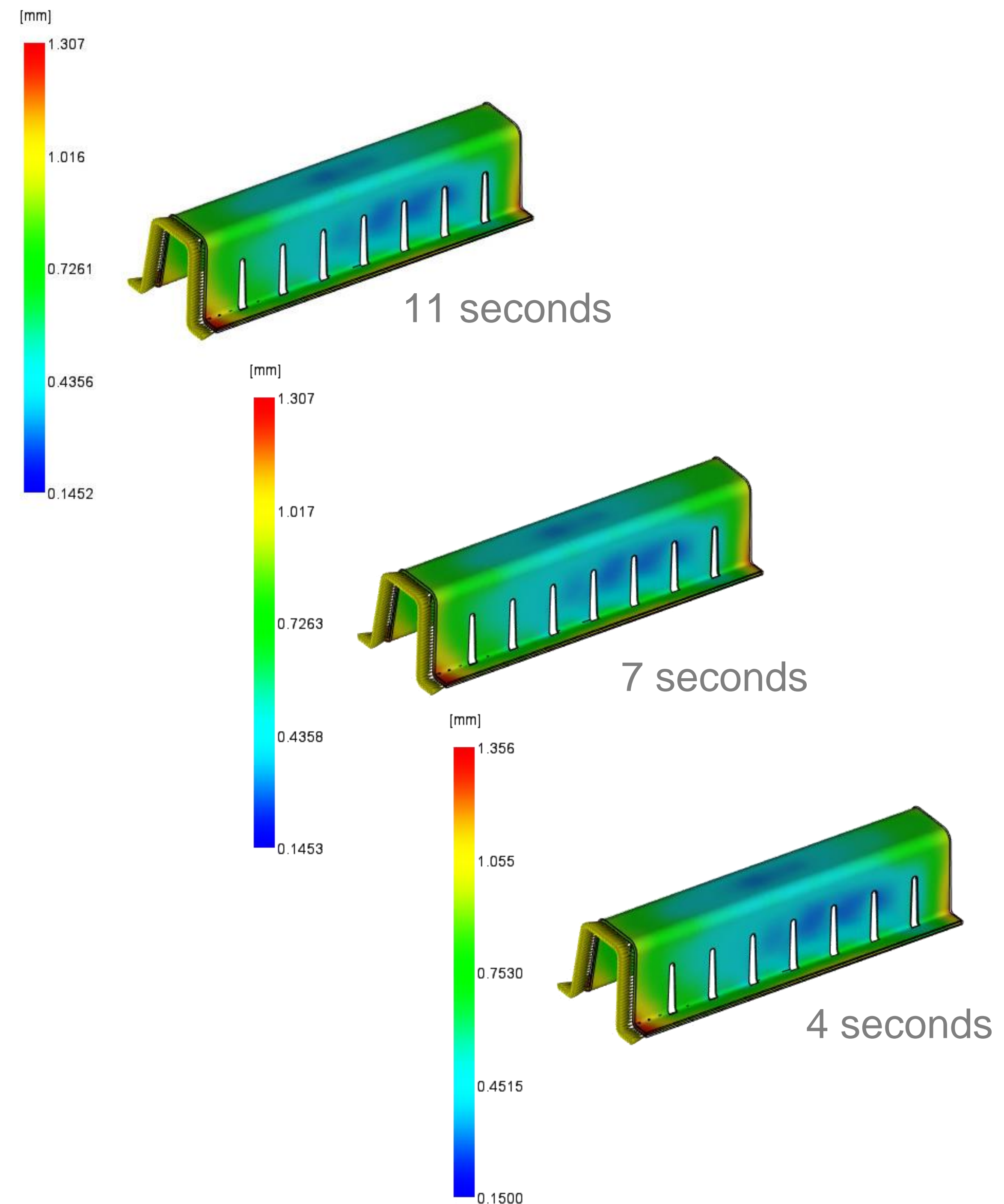




# CASE STUDY

## Packing Pressure & Warpage

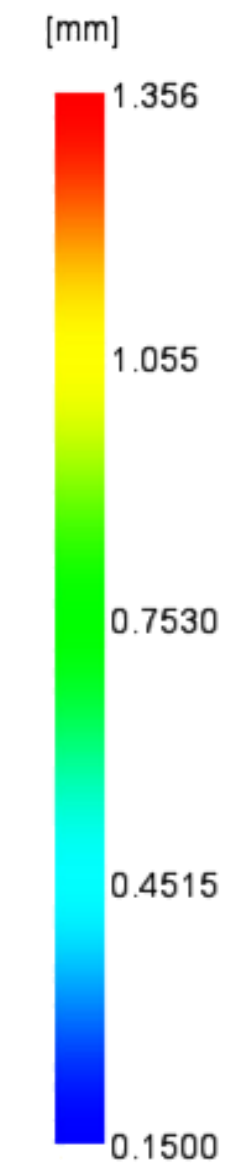
- As a next step 3 different packing pressures are being compared
- 11 s – 7 s – 4 s
- The packing pressure has a significant effect on the warpage of non fiber filled materials
  - With our fiber filled polypropylene no big difference in warpage can be seen through the packing pressure duration
- The customer could think about reducing the packing pressure time to 4 seconds (equal to almost 70 % reduction)



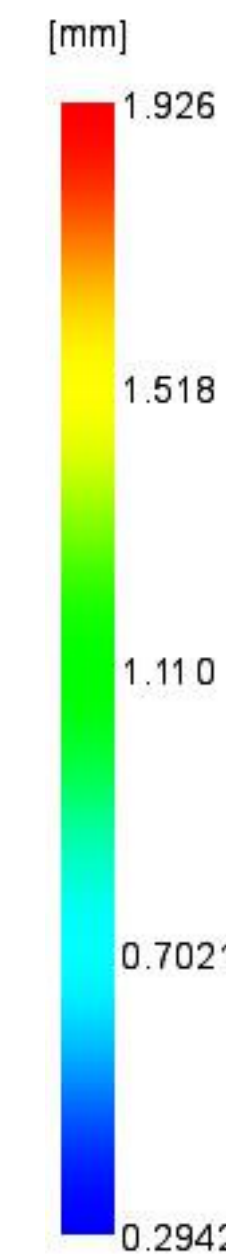
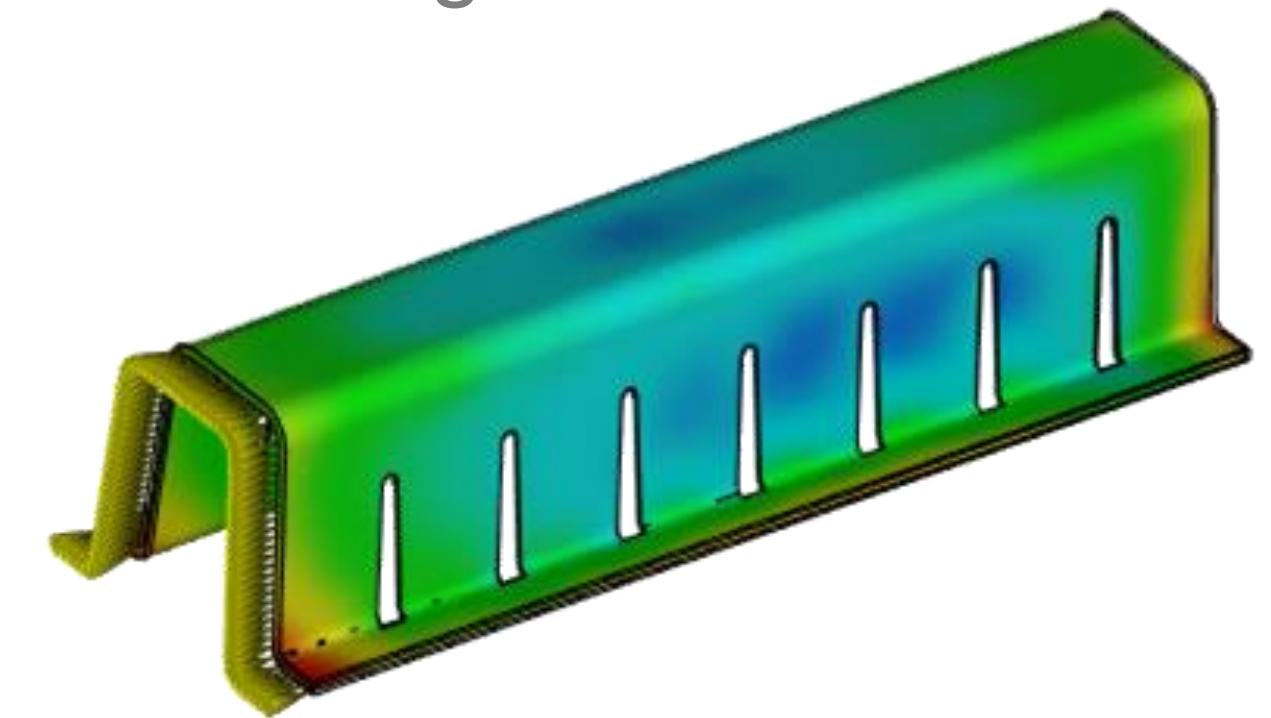
# CASE STUDY

## Packing Pressure & Warpage (Fibers vs. Unfilled)

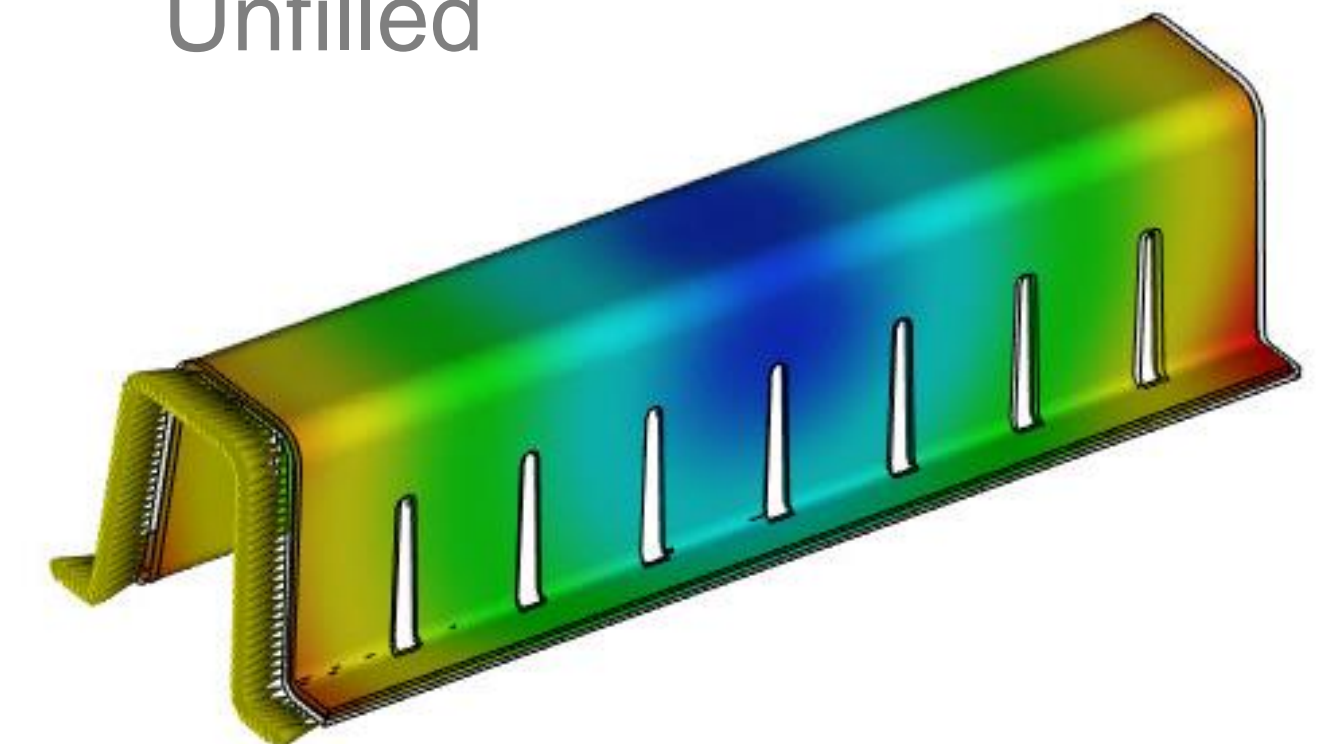
- Effect of non-sufficient packing pressure onto unfilled materials
  - Unfilled materials show a very different warpage behaviour and higher deformation values
  - The increase of the warpage values with an insufficient packing pressure on the unfilled PP is 40 %
- Unfilled materials are a lot more influenced by an insufficient packing pressure



30 % glass fibers



Unfilled

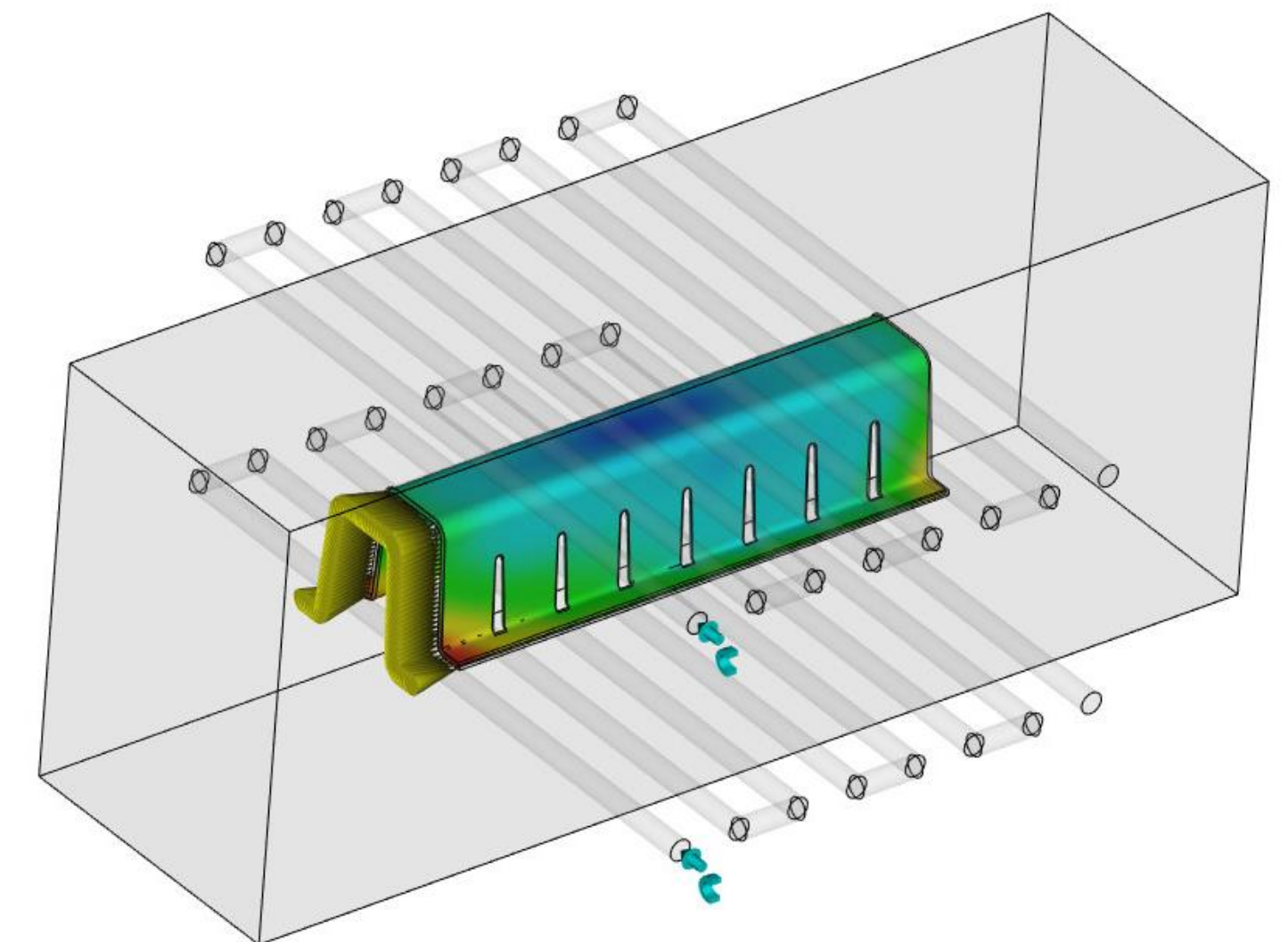
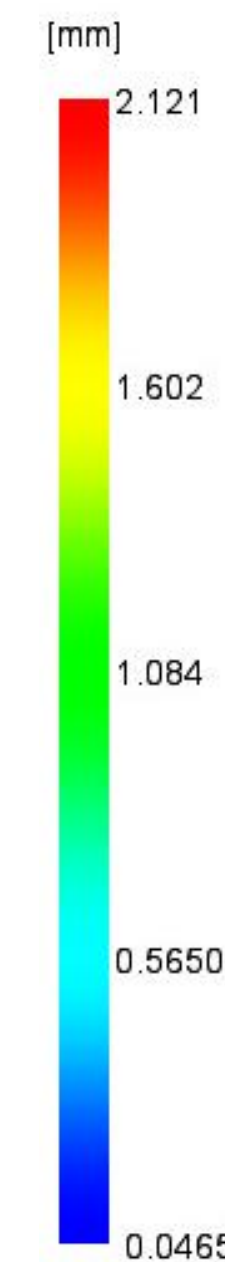
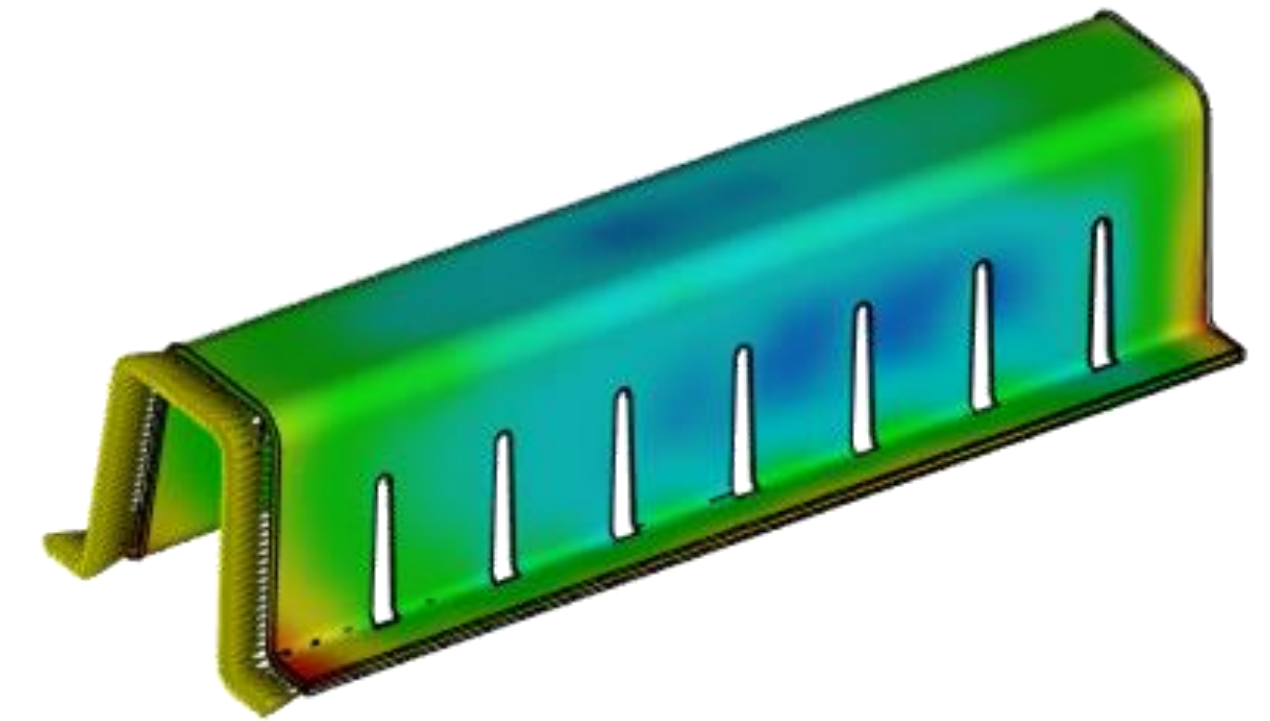
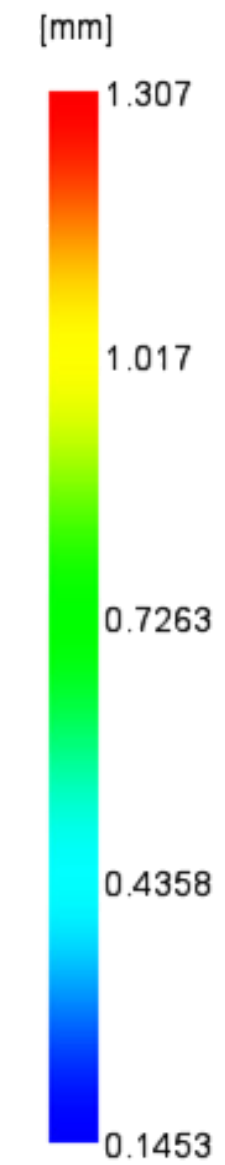




# CASE STUDY

## Cooling System

- Next the cooling system has been added
- With the cooling system the required cooling time and the warpage results increase
- This is due to some areas not being cooled as sufficiently as others
- With (insufficient) cooling included, the warpage values increase by 75 %

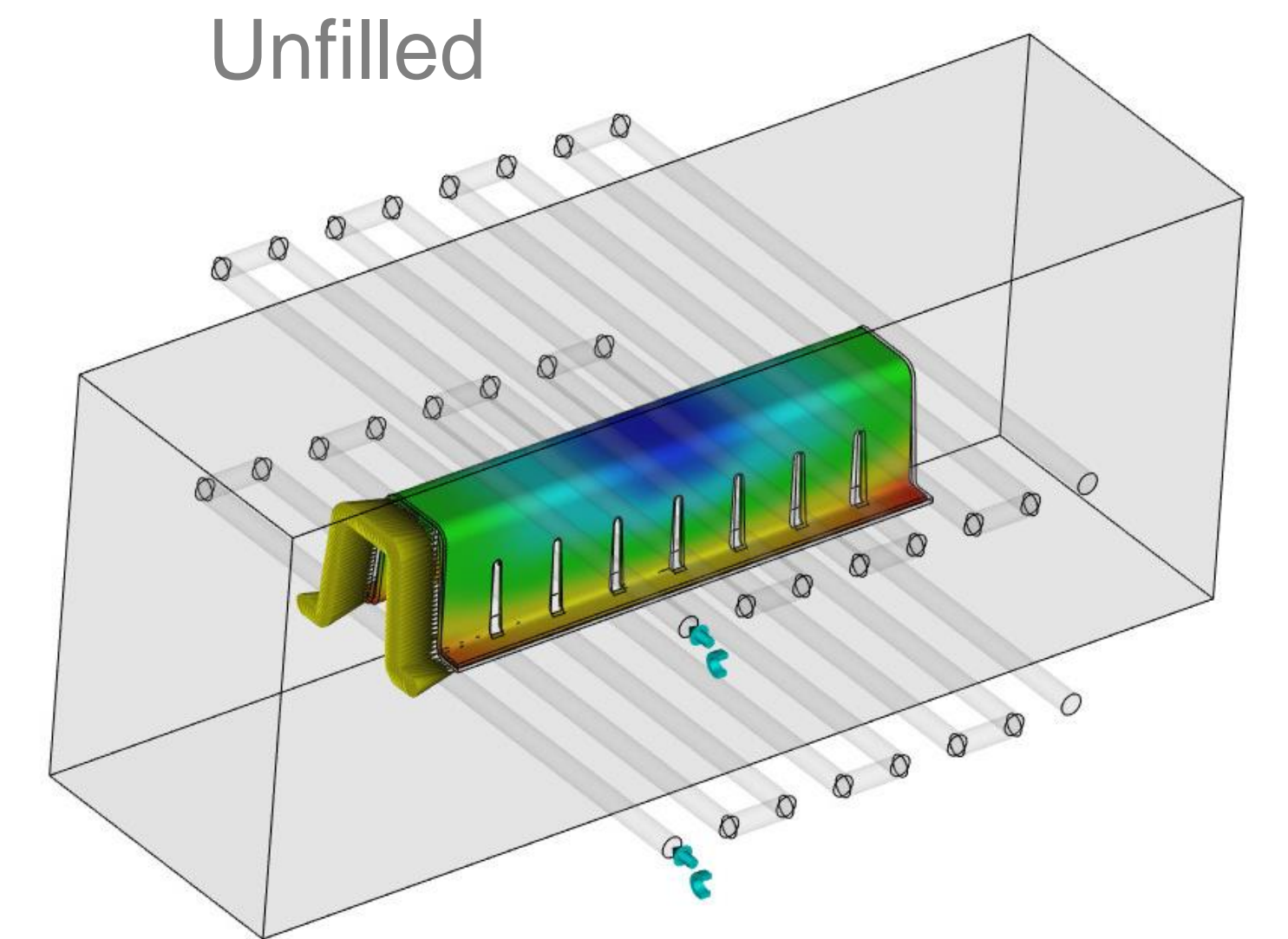
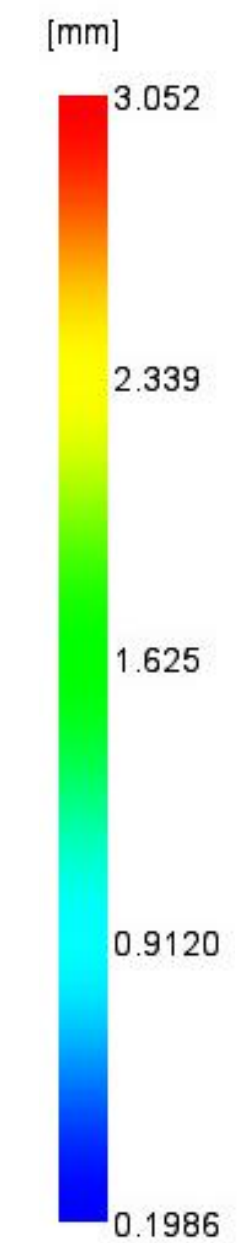
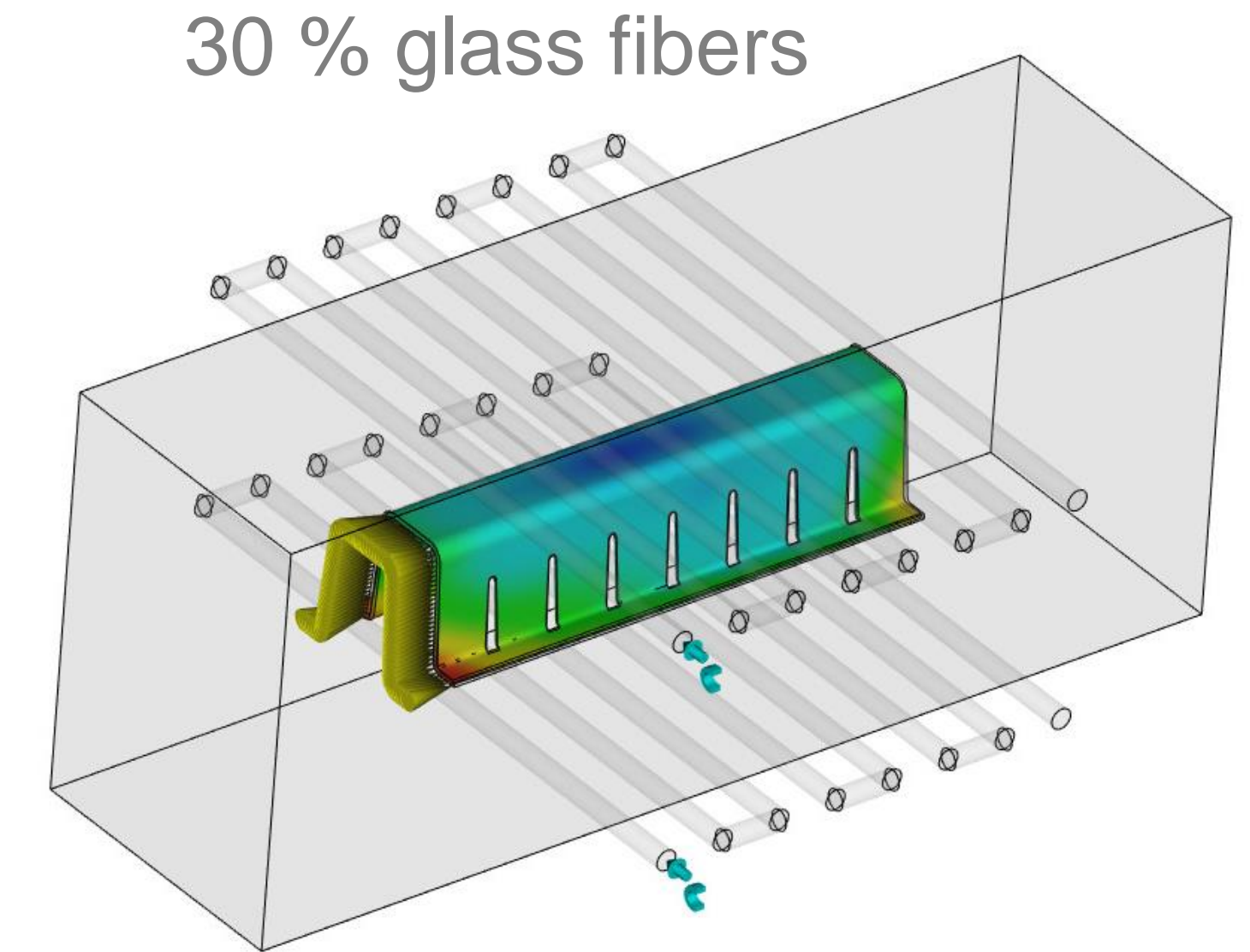
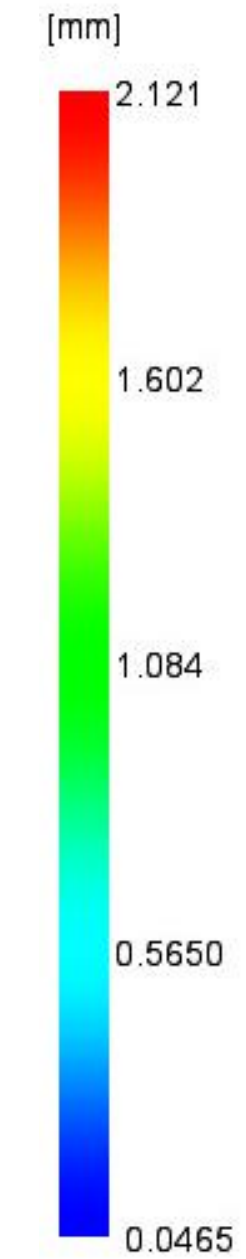


# CASE STUDY

## Cooling System (Fibers vs. Unfilled)

- Here we compare the fiber filled material with the same material without fibers
- The cooling system is included for both studies
- With (insufficient) cooling included, the warpage values of the unfilled PP increase by 35 %

→ Unfilled materials are a lot more influenced by the cooling system!





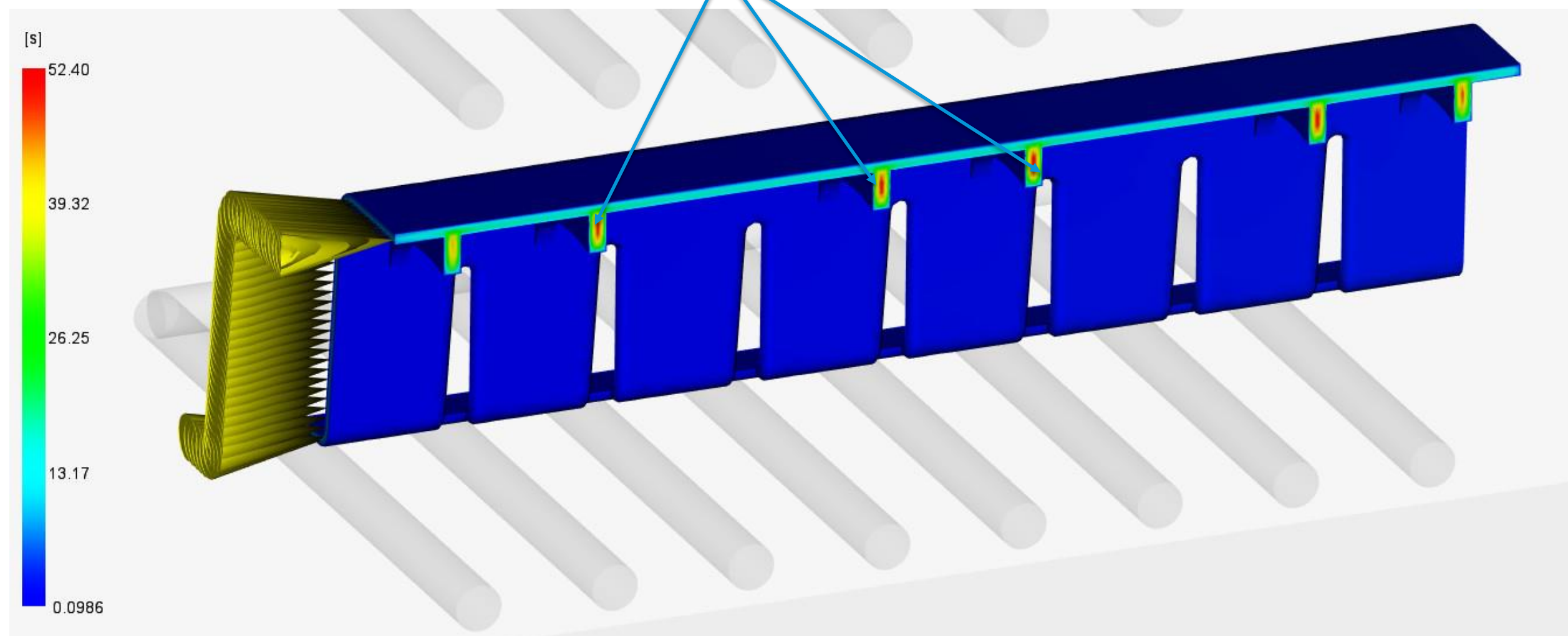
# CASE STUDY

## Geometry Change

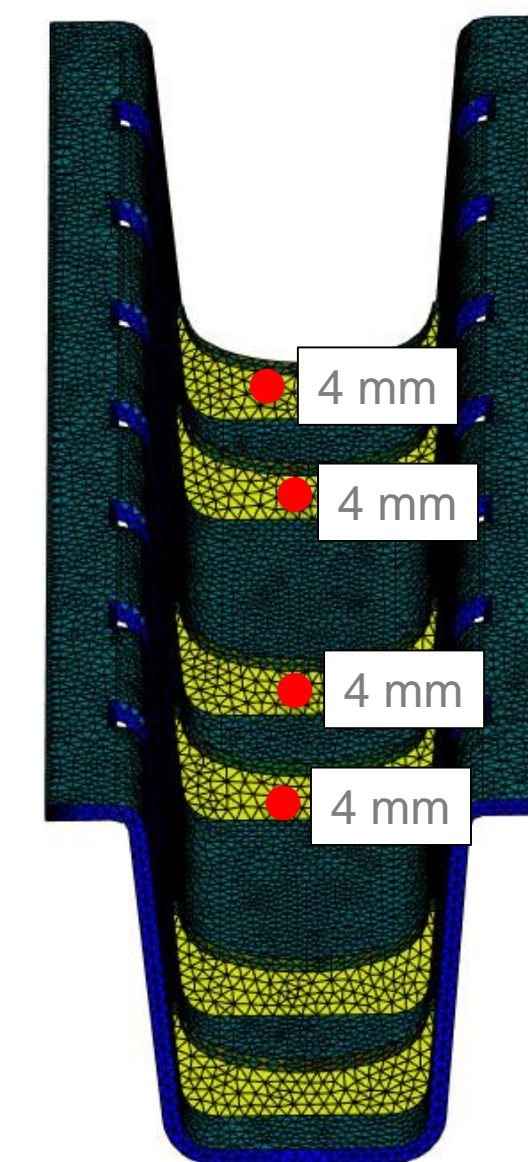
- Including the marginal cooling the warpage values have been sufficient for the customer
- Next step: Wall thickness changes → customer wanted geometry and cycle time improvements

- Cooling time: Thick ribs have the largest impact
- We checked through mechanical simulation, if a wall thickness change from 4 to 2.5 mm is suitable
- After the mechanical simulation it was fine to do so

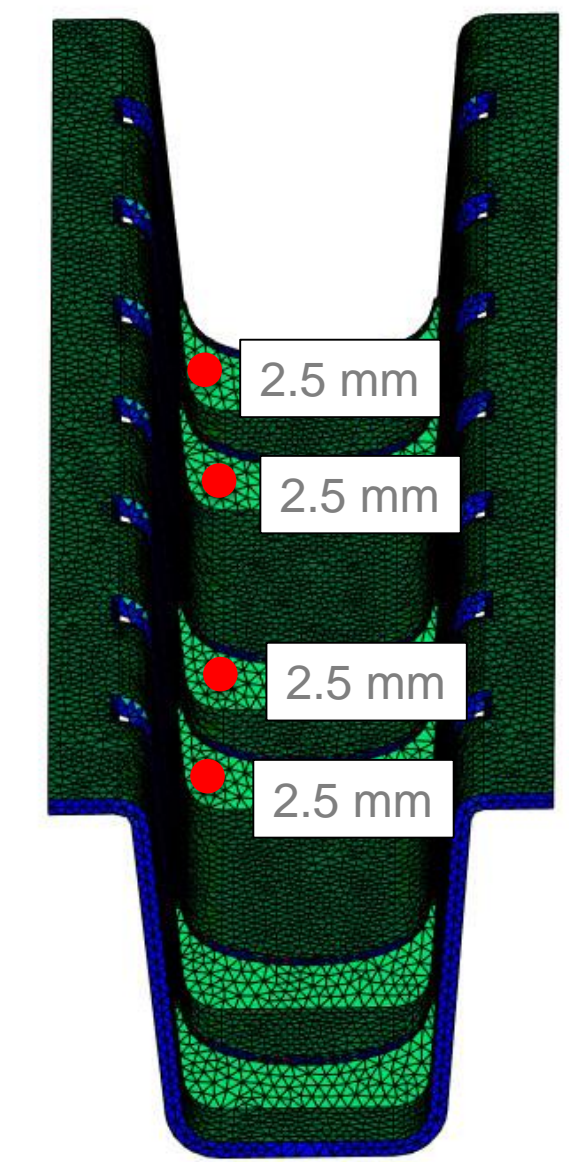
52.4 seconds cooling time



Old geometry



New geometry



# CASE STUDY

## Geometry Change

- Due to the geometrical change also some weight is being spared
- The initial weight was 109 grams, the weight of the new geometry is 106 grams
- This sums up to a total weight reduction of 2.6% or 2.8 grams

Old geometry	Total mass	=	108.9668 g
New geometry	Total mass	=	106.1171 g



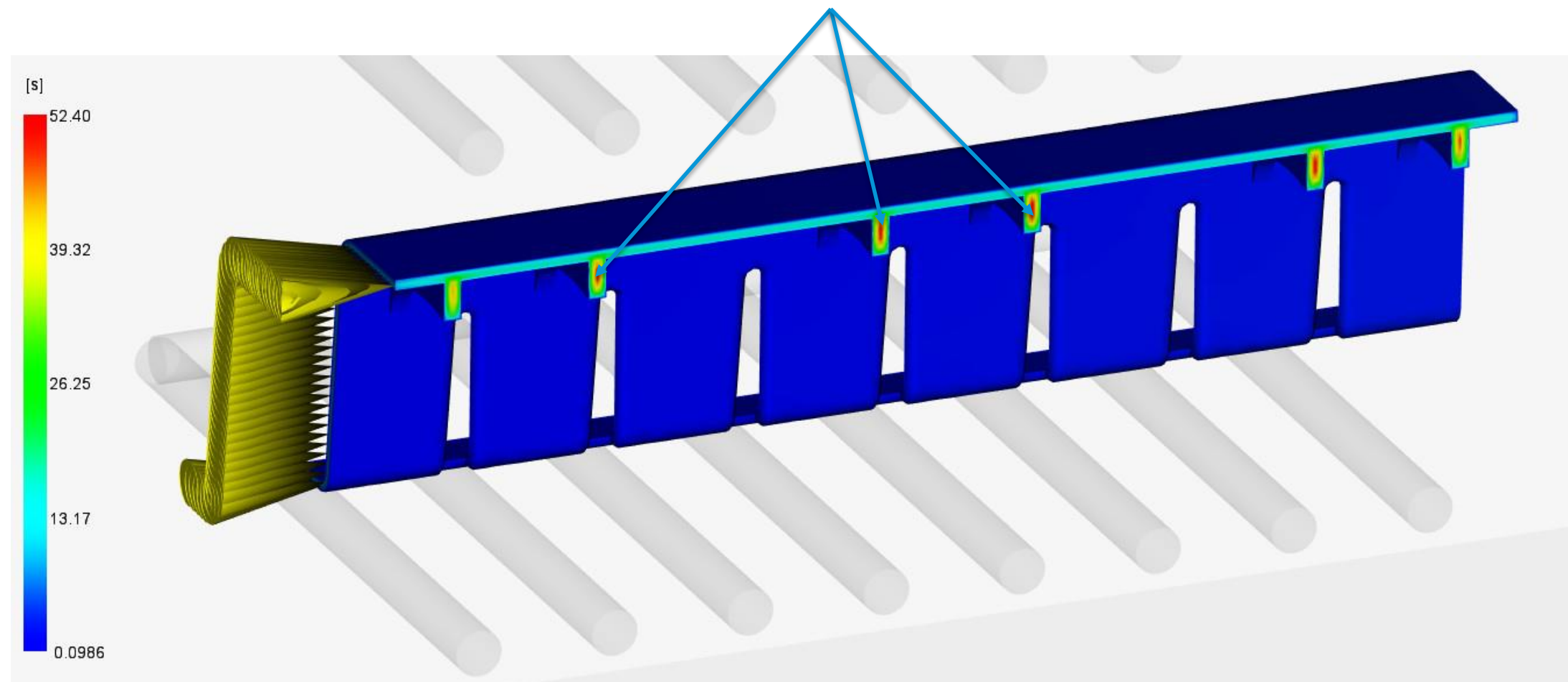
# CASE STUDY

## Geometry Change (Time to Reach Ejection Temperature)

- The new geometry shows only half the cooling time compared to the old geometry

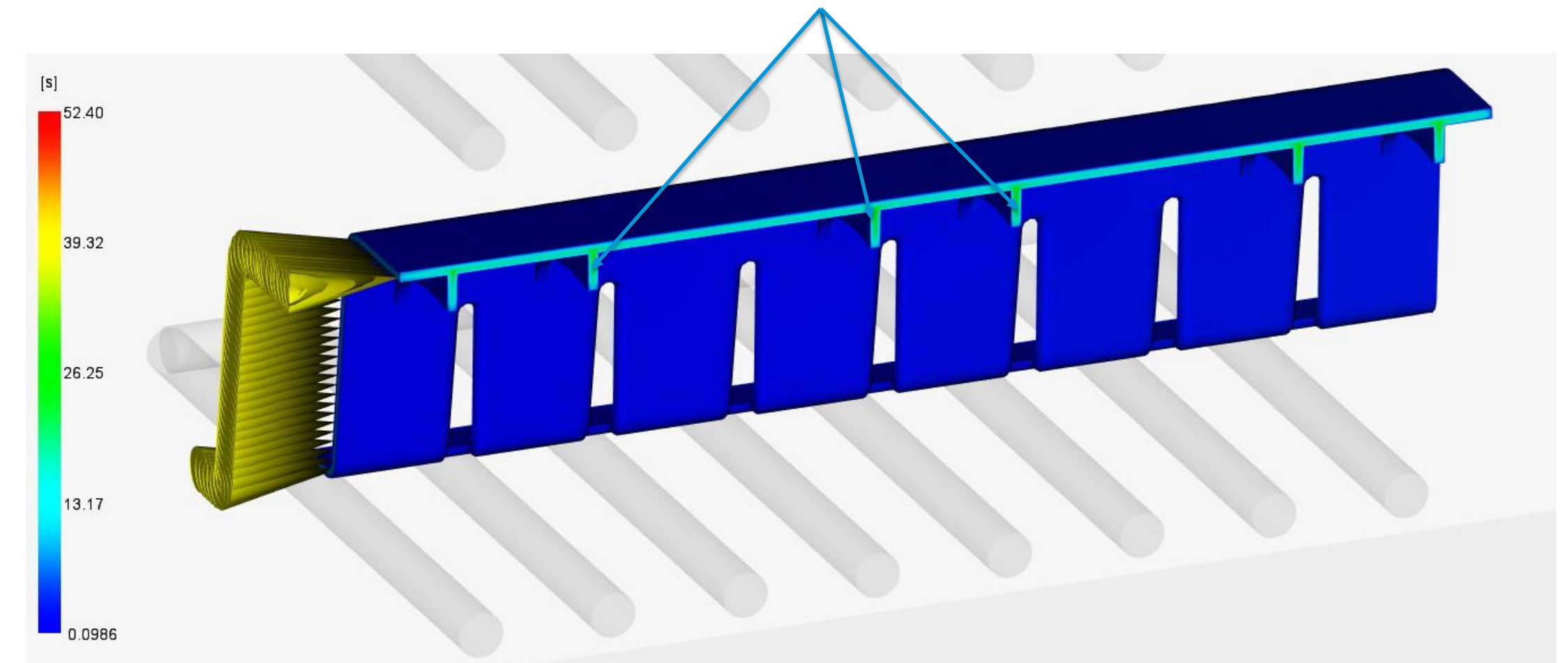
Old geometry

52.4 seconds cooling time



New geometry

26 seconds cooling time

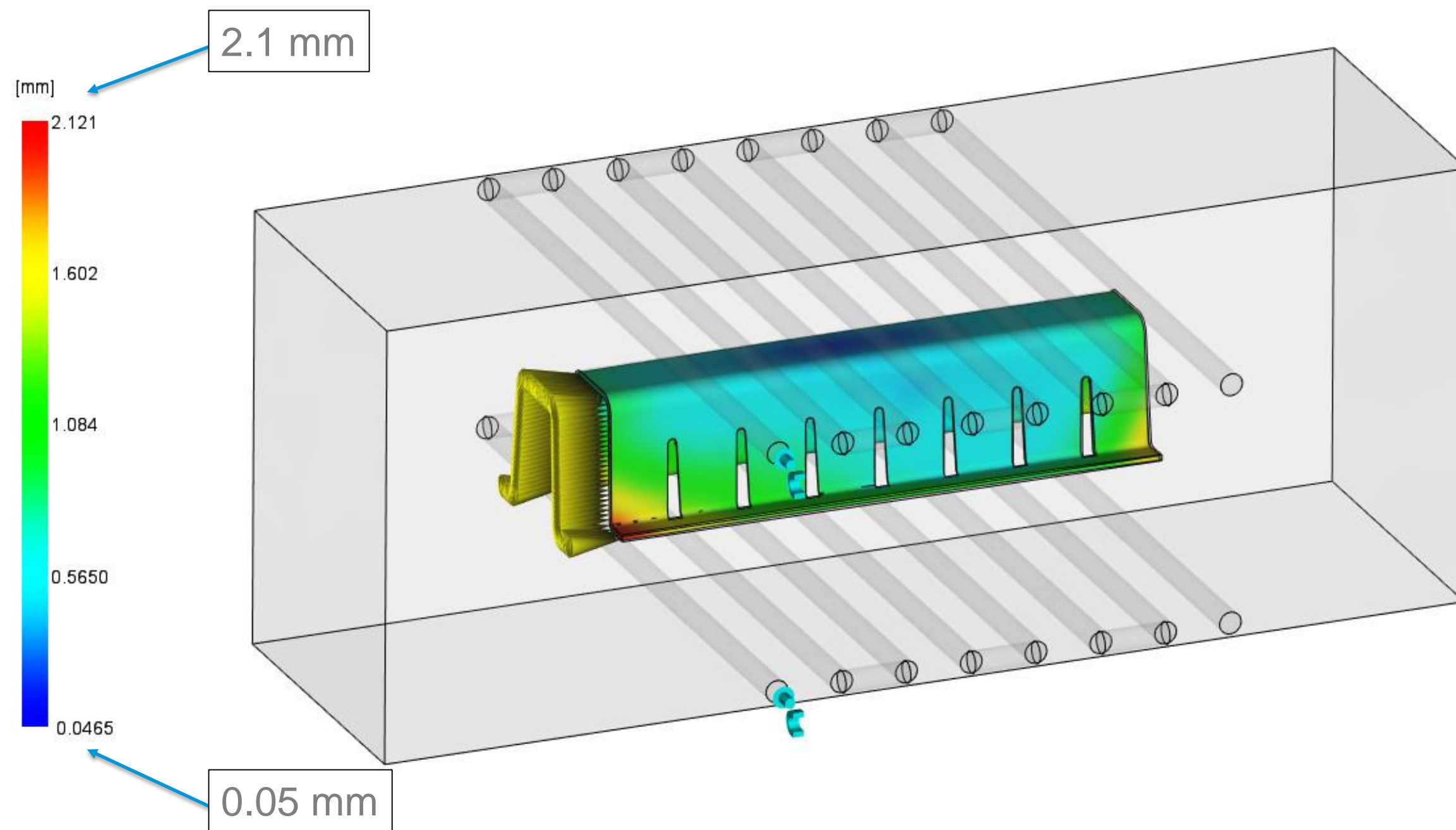


# CASE STUDY

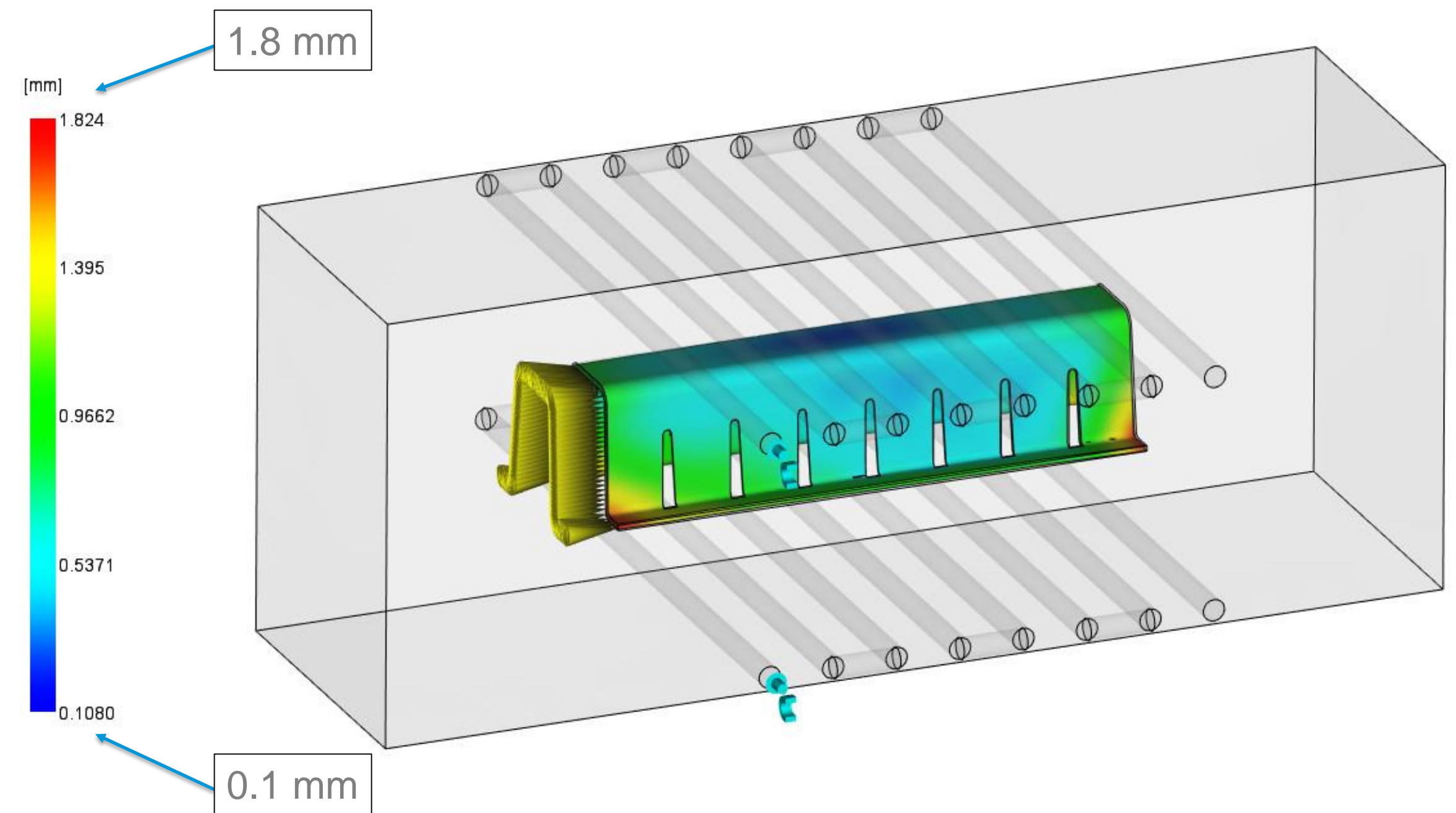
## Geometry Change (Warpage)

- The new geometry shows an additional decrease in warpage by around 20 %

Old geometry



New geometry





# FACTS AND FIGURES

**70%**

PACKING PRESSURE  
REDUCTION

**50%**

COOLING TIME  
REDUCTION

**20%**

TOTAL WARPAGE  
REDUCTION

**2.6%**

WEIGHT  
REDUCTION

# SAVING POTENTIAL

- Modification Loop of Mold (first year only) 30.000 €
- Reduced Rib Wall Thickness onto Material Saving:
  - material saving 2.6 %
  - savings per part 0.005 €
  - savings per year 2,400 €
- Overall Process Identification and Optimization onto Cycle Time:
  - cycle time saving 26 s / 50 %
  - savings per part 0,251 €
  - savings per year 126,530.00 €
- Saving 1. Year 158,930.00 €
- Saving 5 Years Tool Lifetime 674,650.00 €
- 10 Tools / Year 6,746,500.00 €

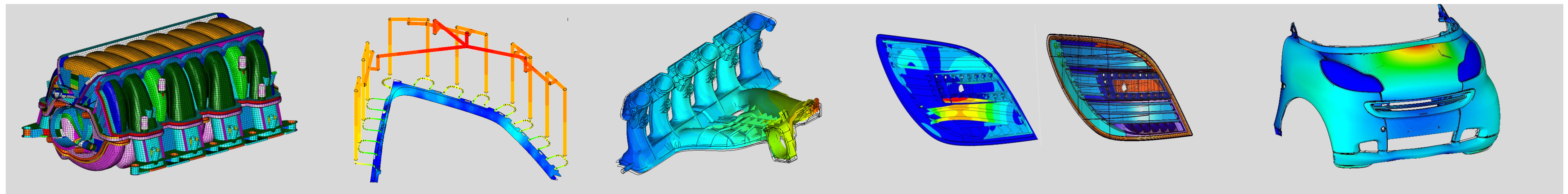




# MOTIVATION

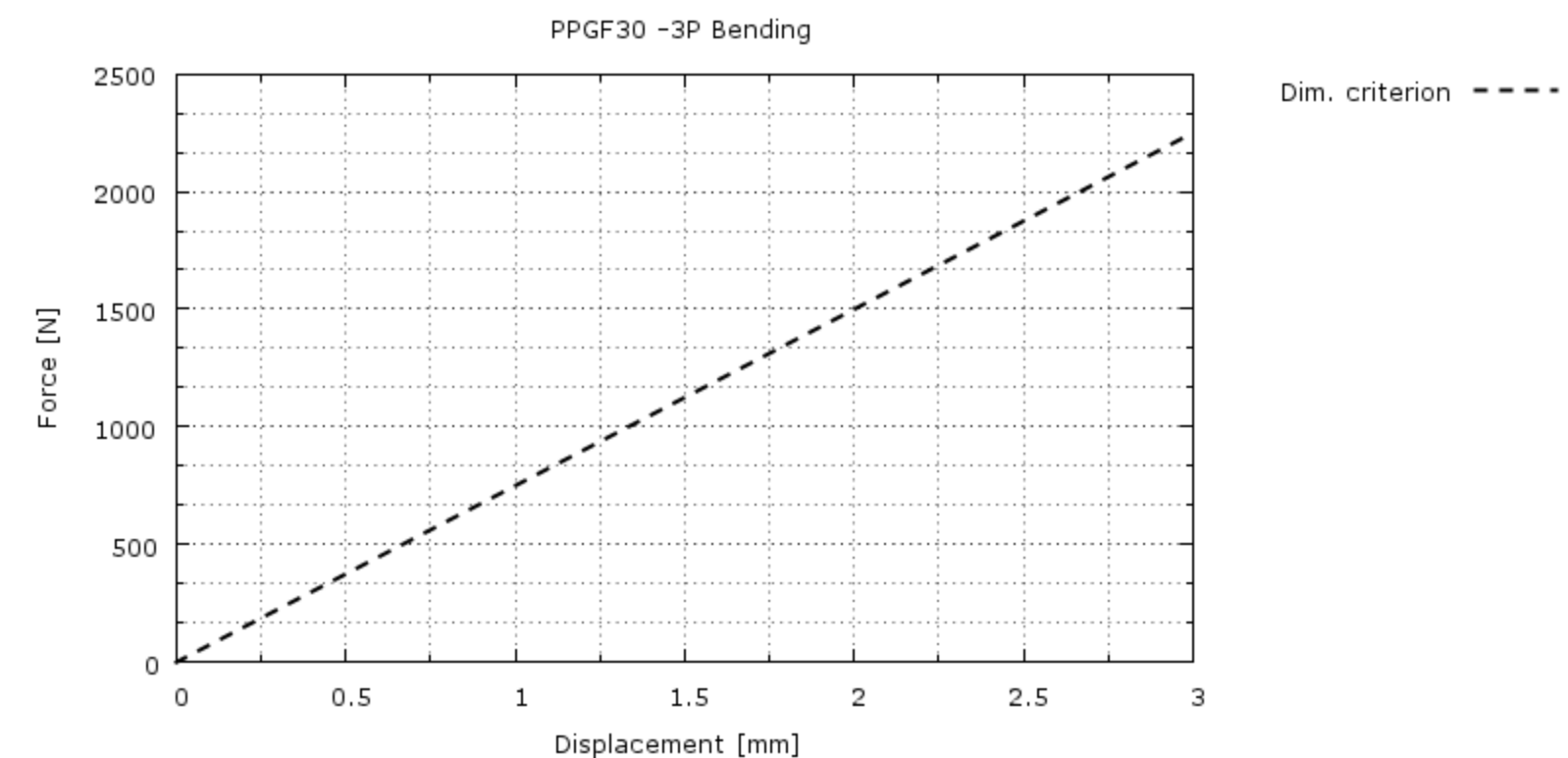
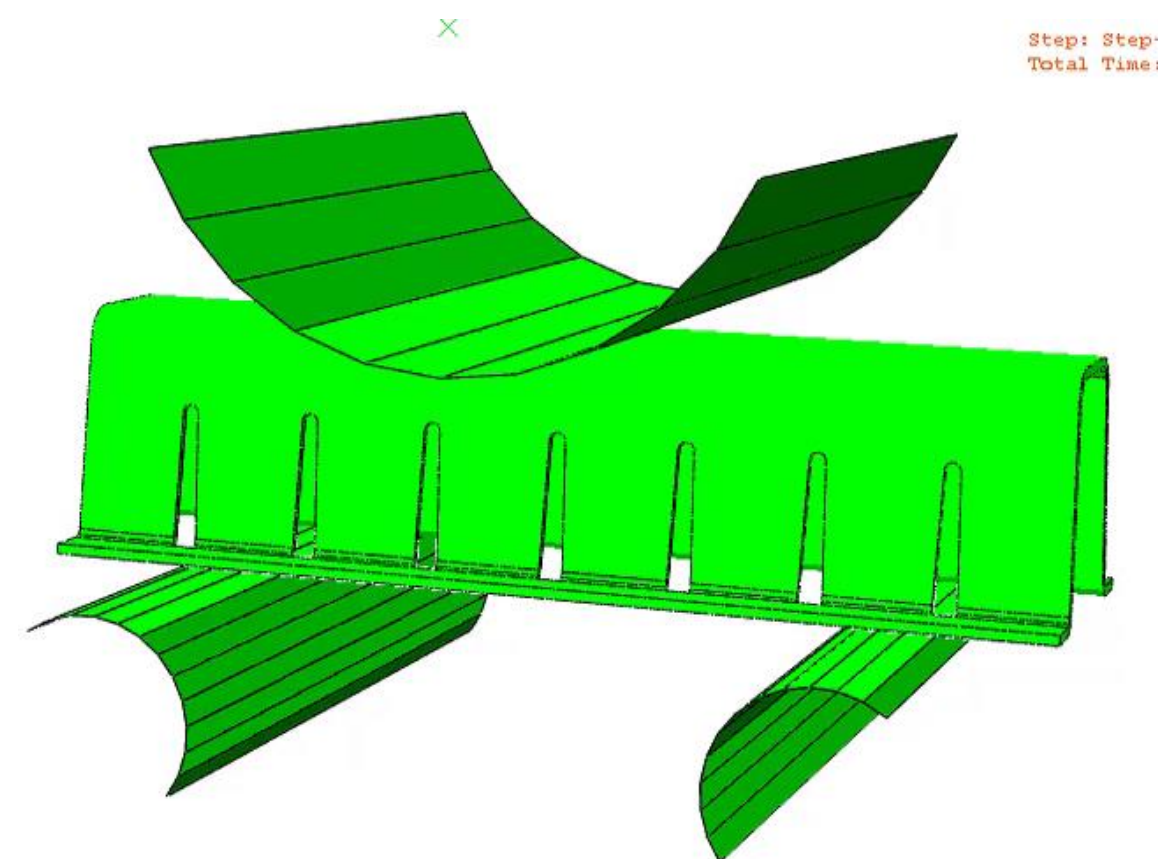
Due to systematic use of simulations our customers generally achieve

- shorter development times
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  - increased part and mold quality
- elaborate advantages to competitors



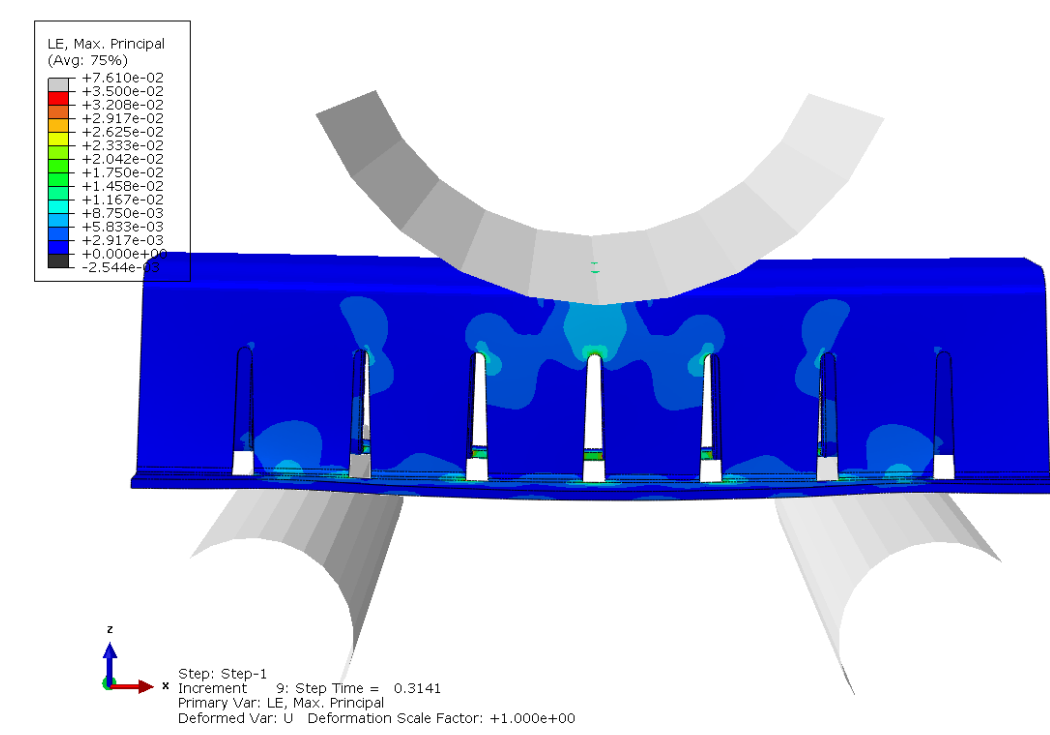
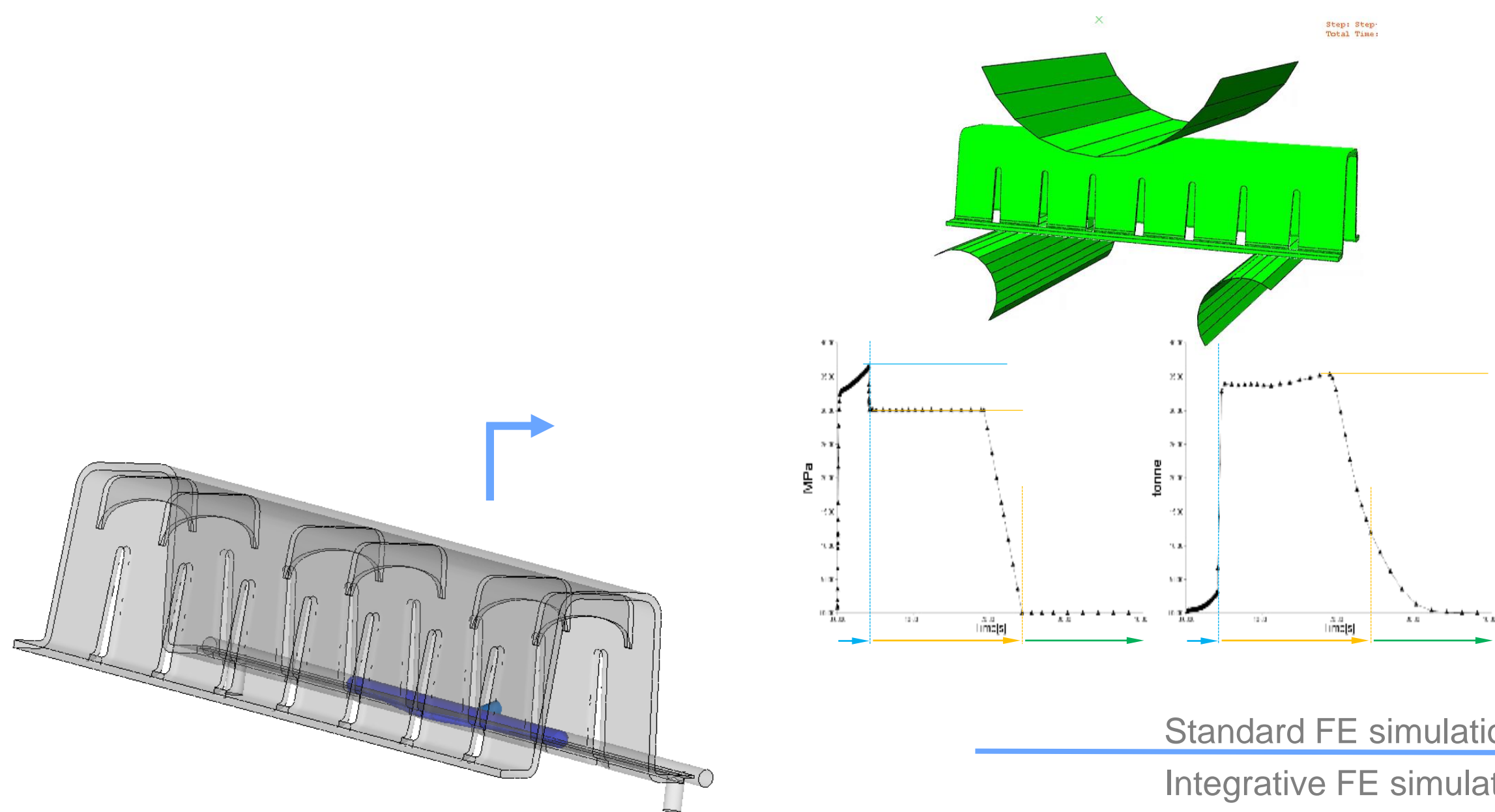
# Case Study and Dimensioning Criterion

- **Imaginary Engineering Task**
  - U-profile subjected to 3 point bending
  - dimensioning criterion is a defined bending stiffness
  - material is a PP GF 30%
- **Load Case**
  - loose bearing (top) has displacement boundary condition
  - fixed bearings (bottom) have rotational freedom around axis
- **Moldflow for Process Reliability**
- **FEM for Design Reliability**

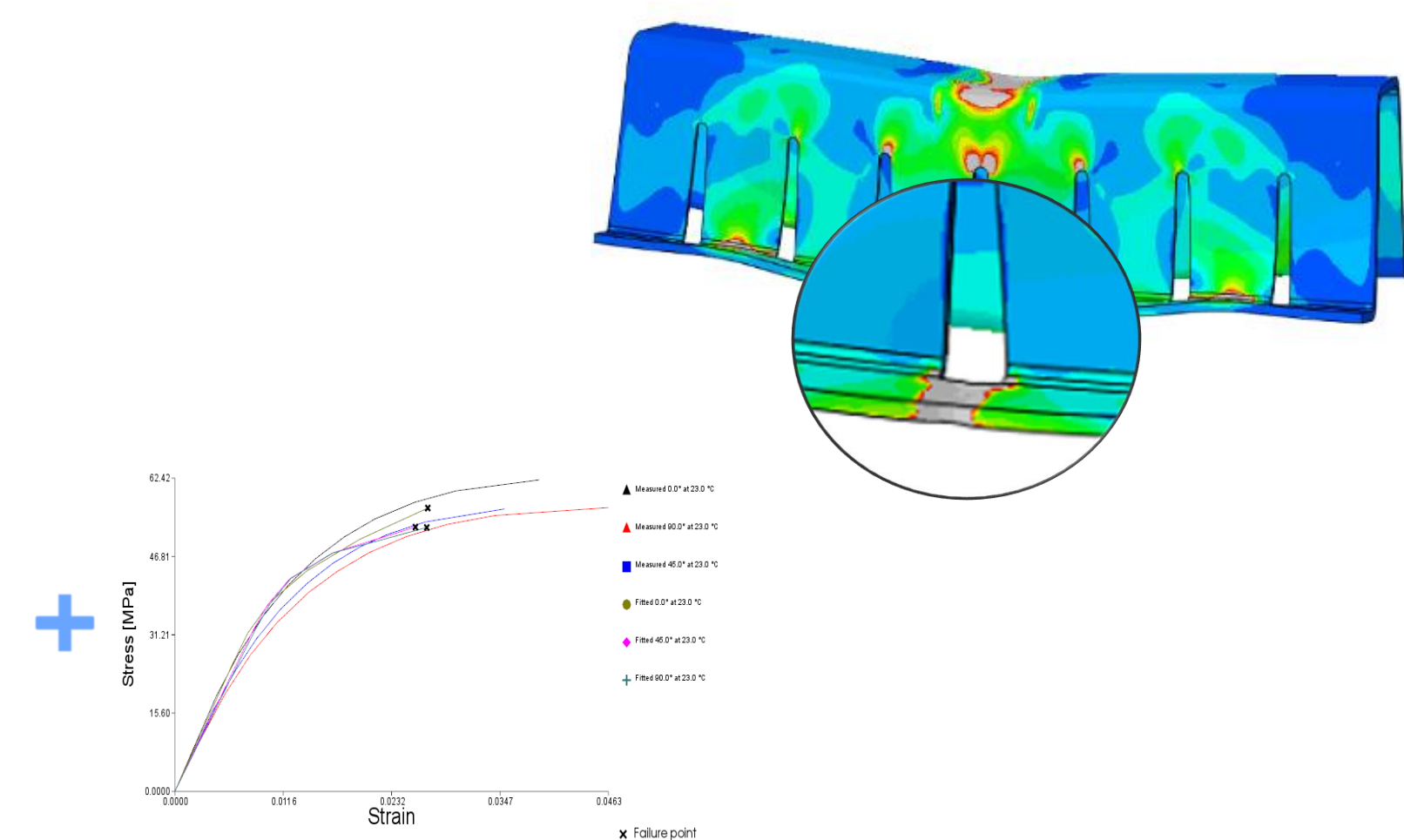
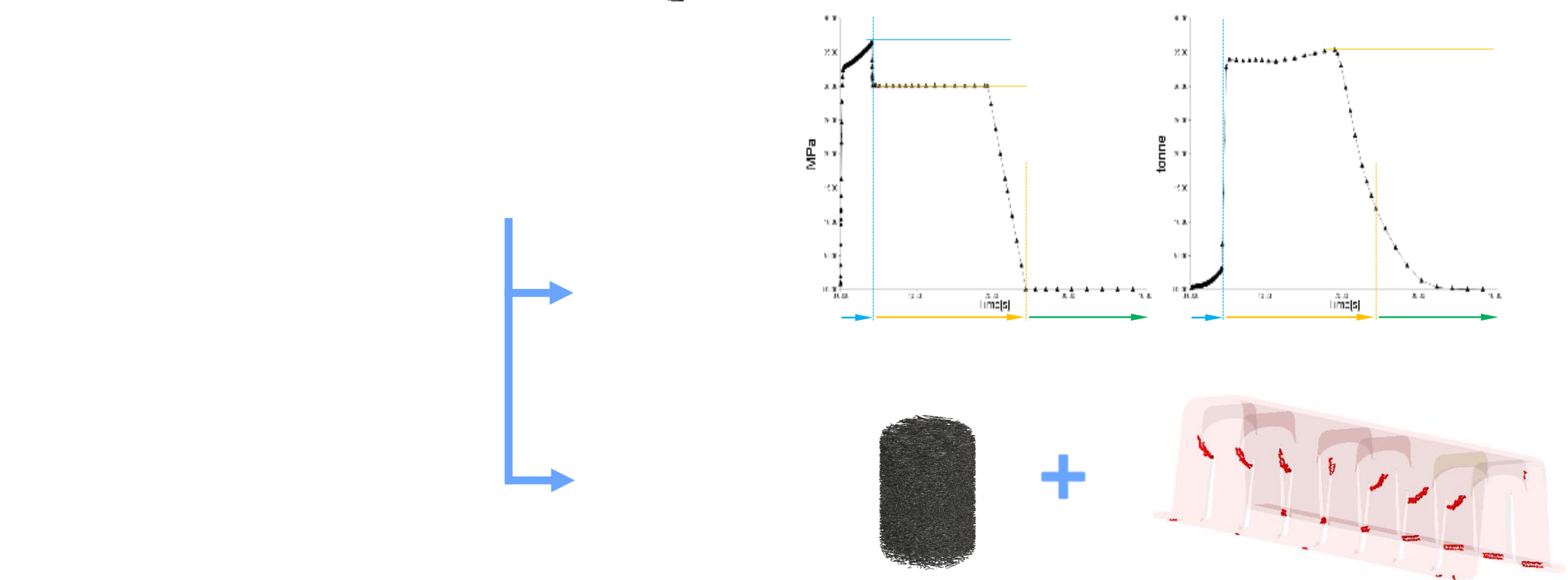




# Simulation Strategies



Strain distribution with **isotropic** material model, which does not consider any microstructure resulting from injection molding process.

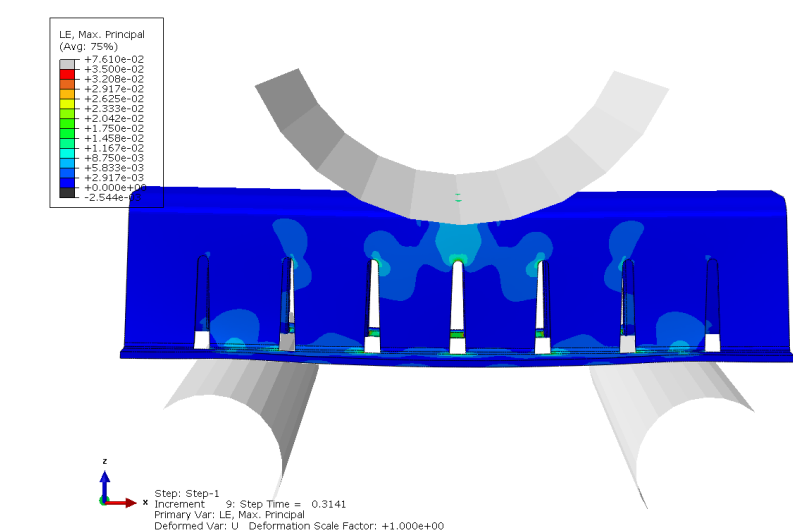
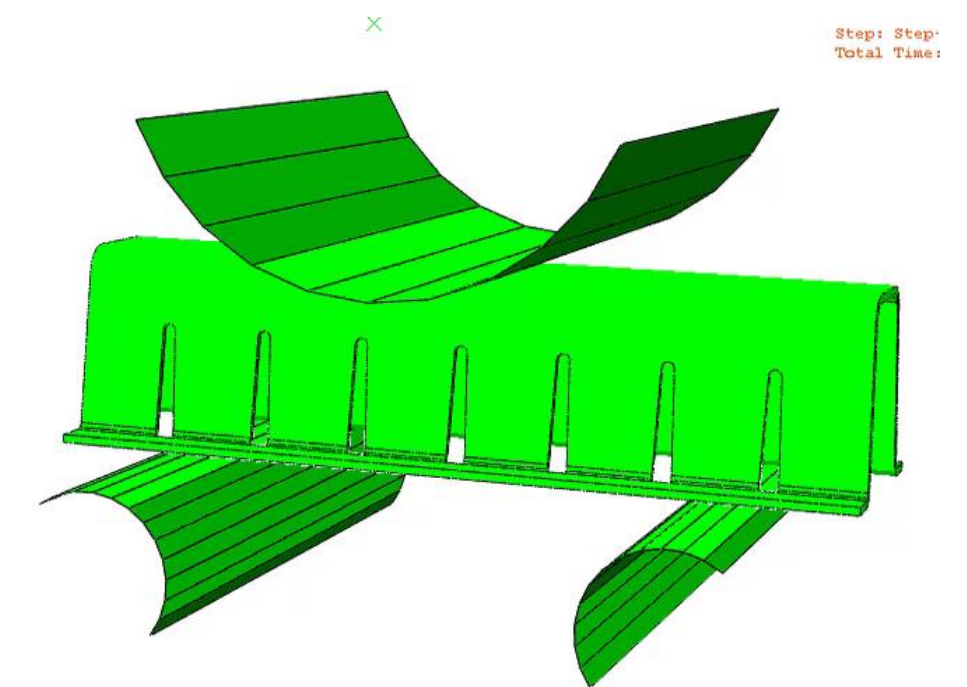
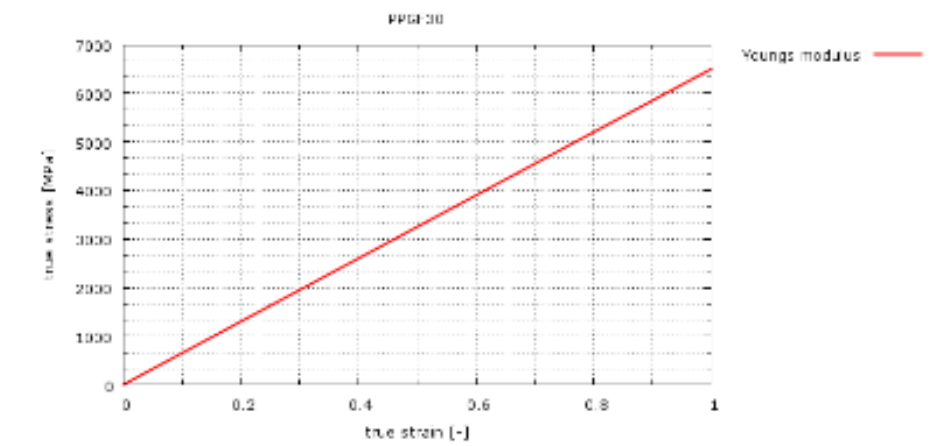
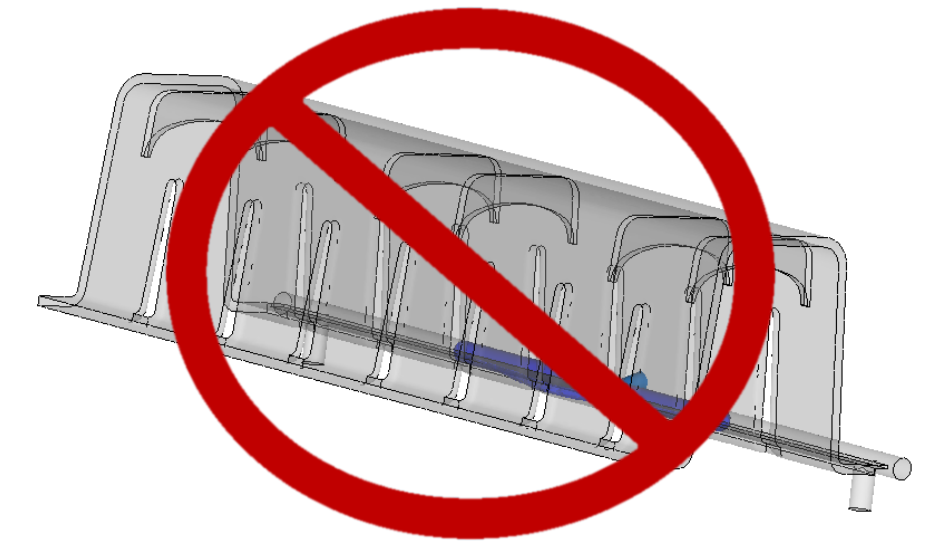


Strain distribution with **anisotropic** material model, which considers the microstructure resulting from injection molding process.

- Detecting of constructive or process induced weaknesses
- Identification of light-weight potential

# Uncoupled Solution

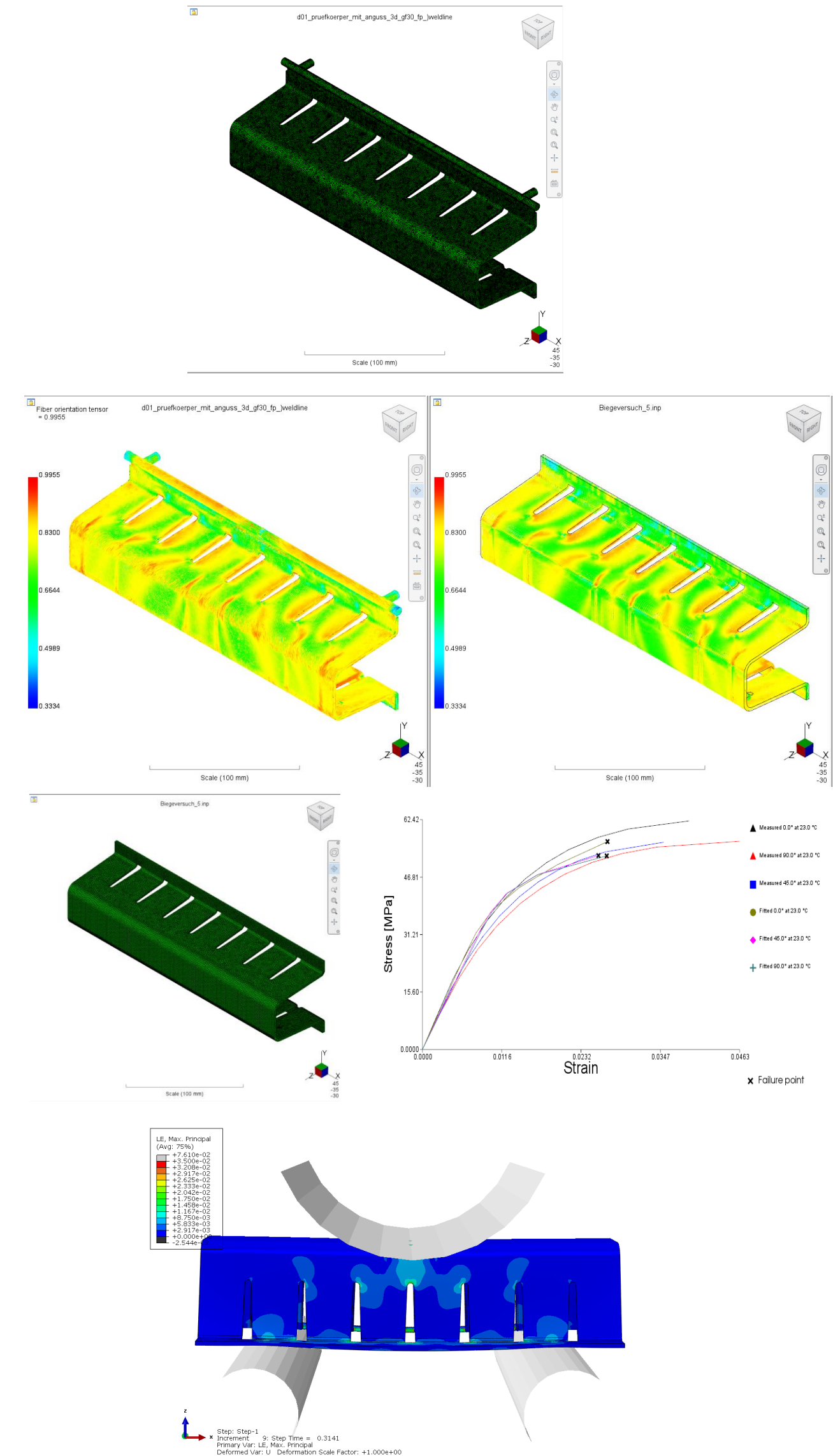
- **Moldflow Analysis for Part, Mold, Runner- and Cooling System**
  - ▶ process information available, but unused
- **Set up FEM Model**
- **Reduction Factor for Young's Modulus Based on Experience**
  - to account for anisotropic behavior
- **Isotropic Linear Elastic Material Model**





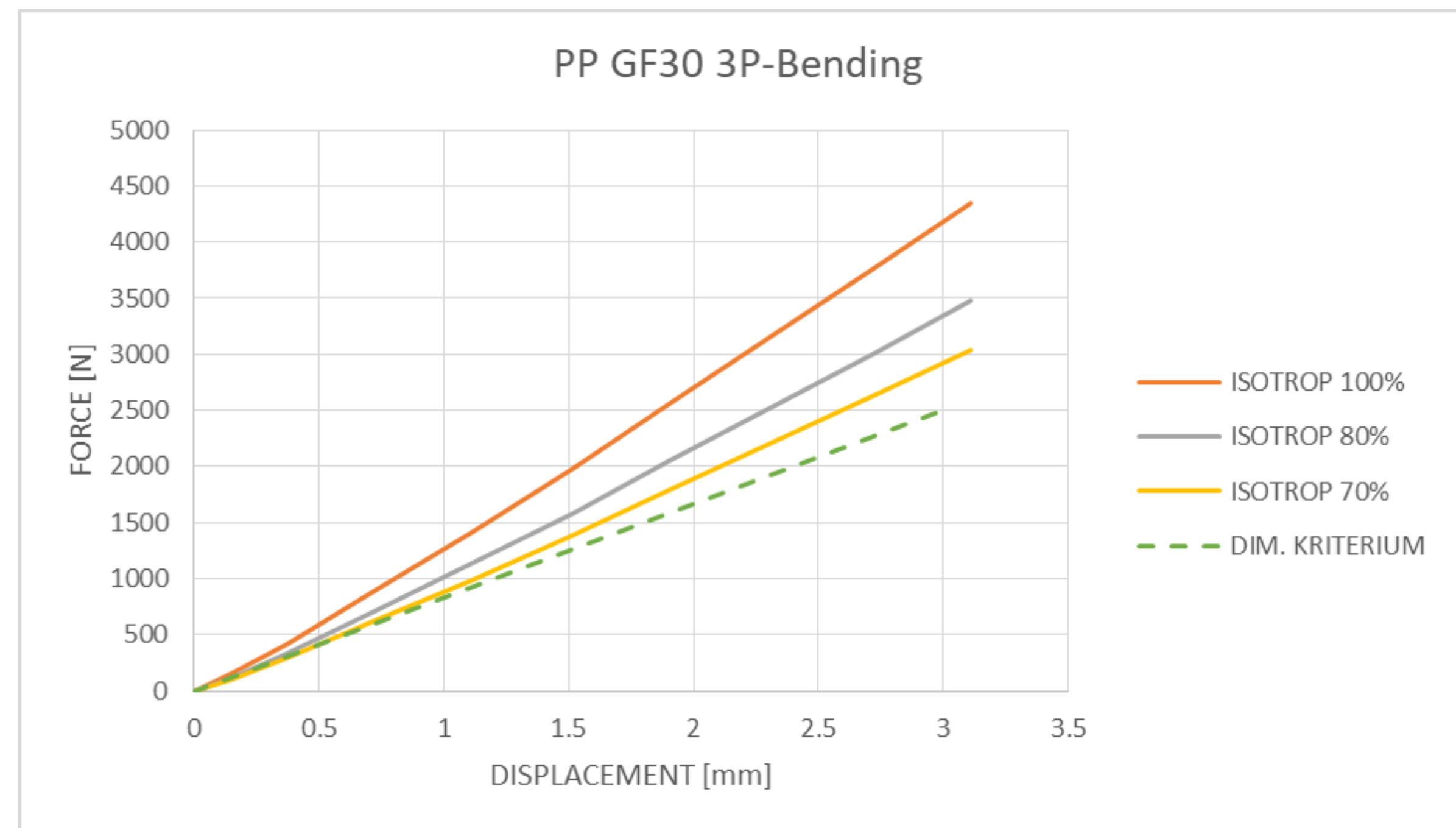
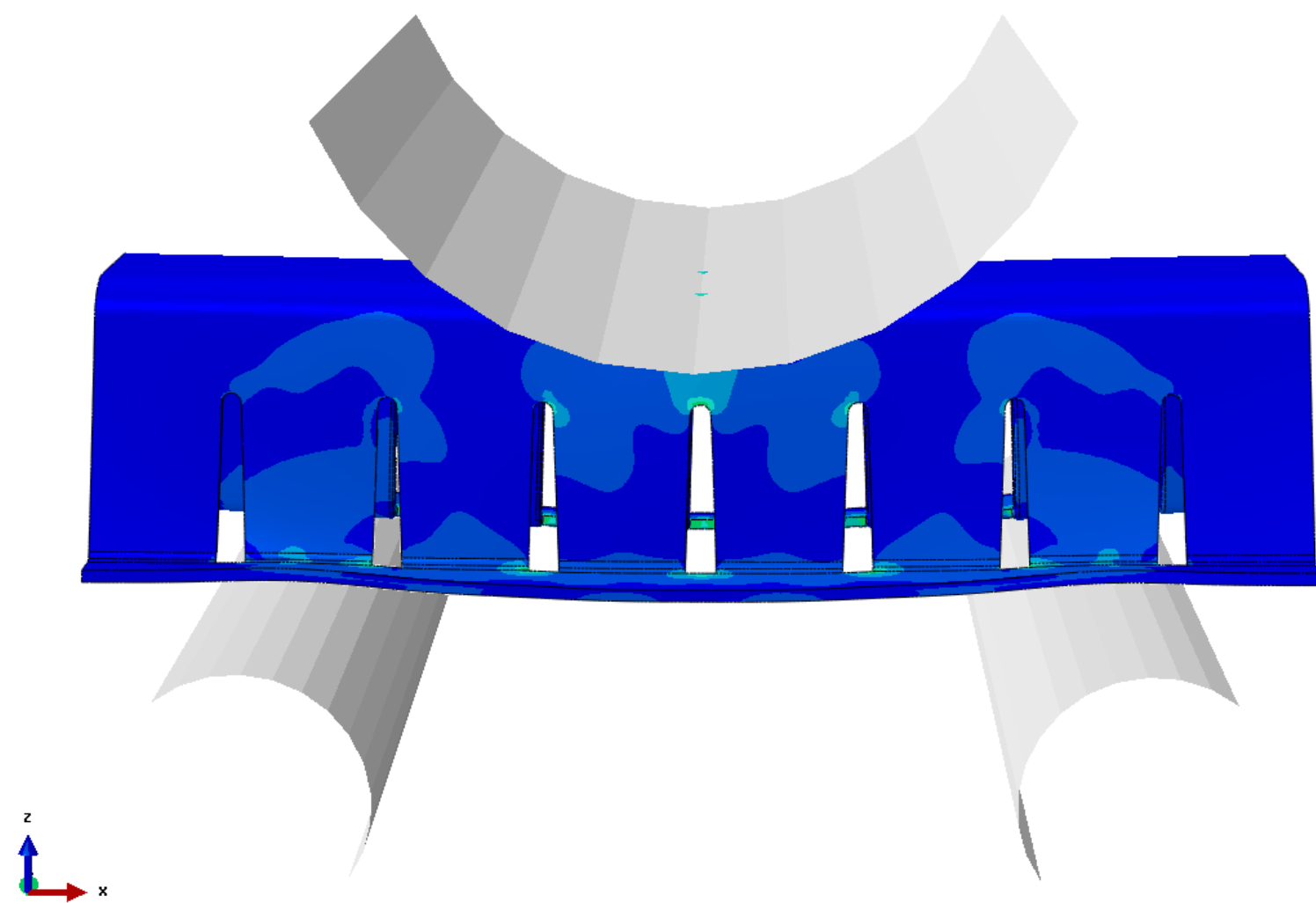
# Coupled Solution – Autodesk Heliux

- Moldflow Analysis for Part, Mold, Runner- and Cooling System
- Set up FEM Model (Dummy Materialmodel)
- Import Structural Model, Injection Model and Process Information
- Automatic Reverse Engineering Material Model
- Anisotropic Elastic-Plastic Material Model
- Mapping of Process Data to Structural Model



# Results – Uncoupled Solution

- Stiffness of Part Decreasing with Higher Reduction Factor
- Dimensioning Criterion Satisfied

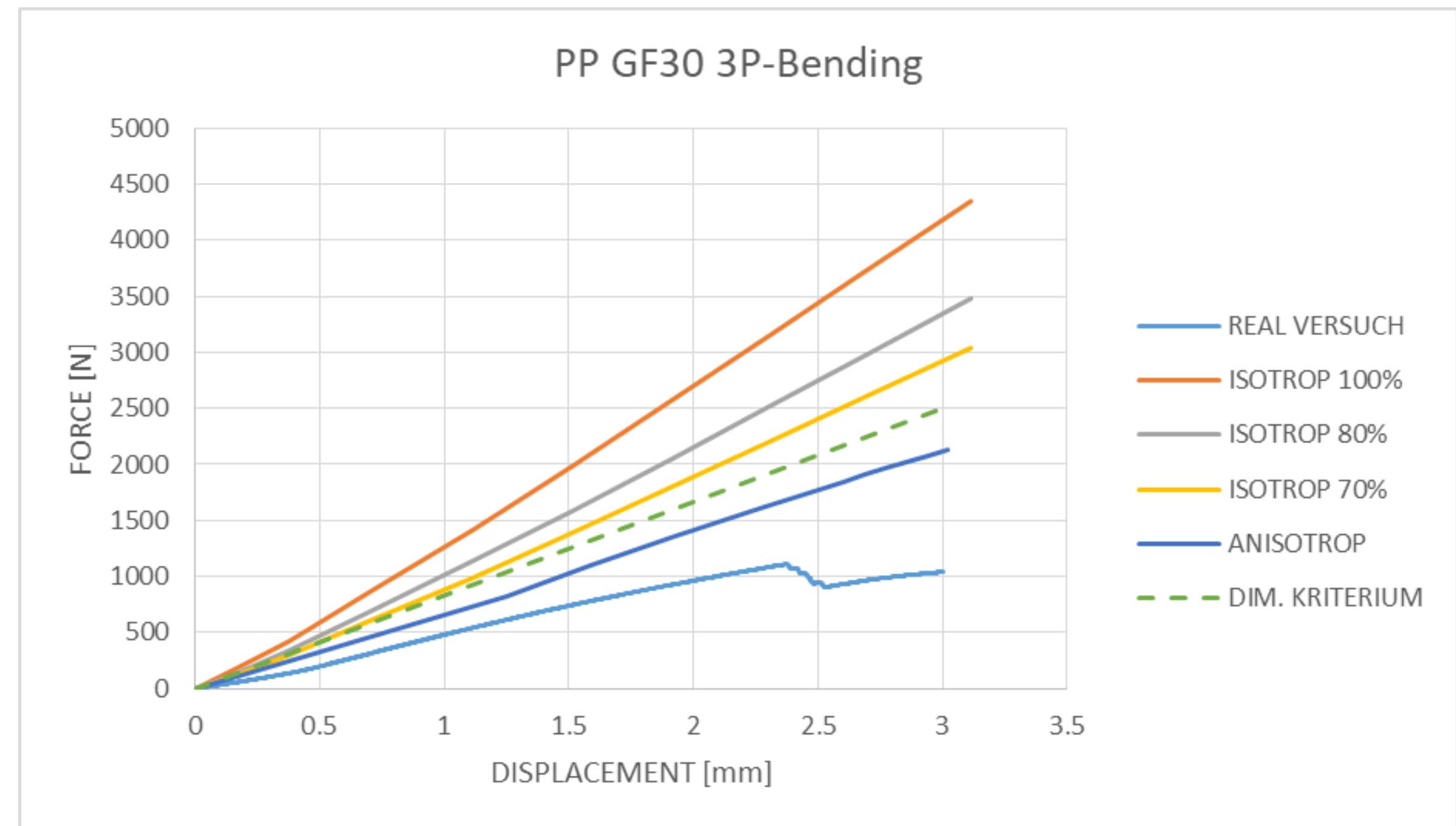
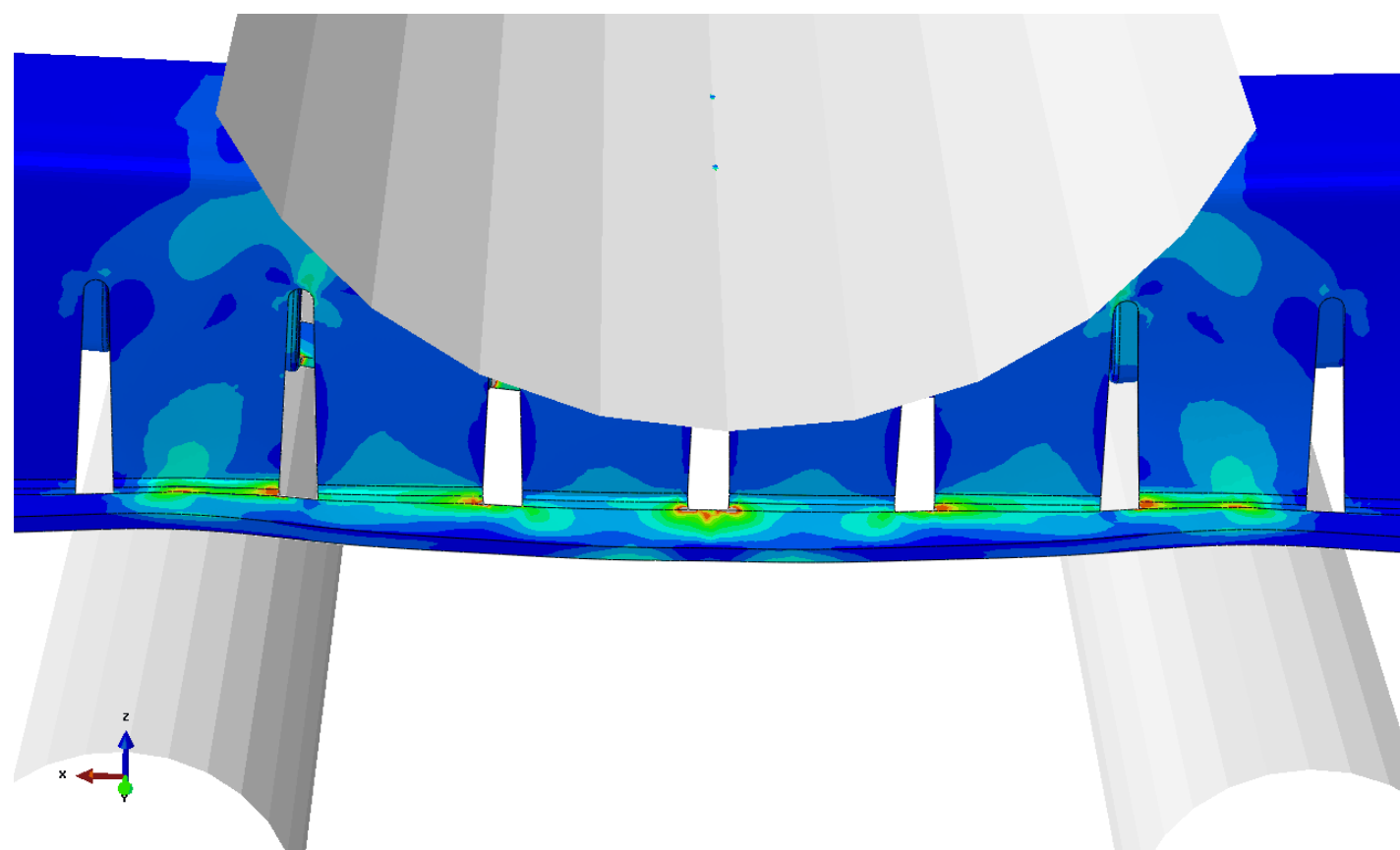




# Results – Coupled Solution – Helius

- Stiffness of Part Lower than in Uncoupled Solution
- Strain Distribution Different from Uncoupled Solution

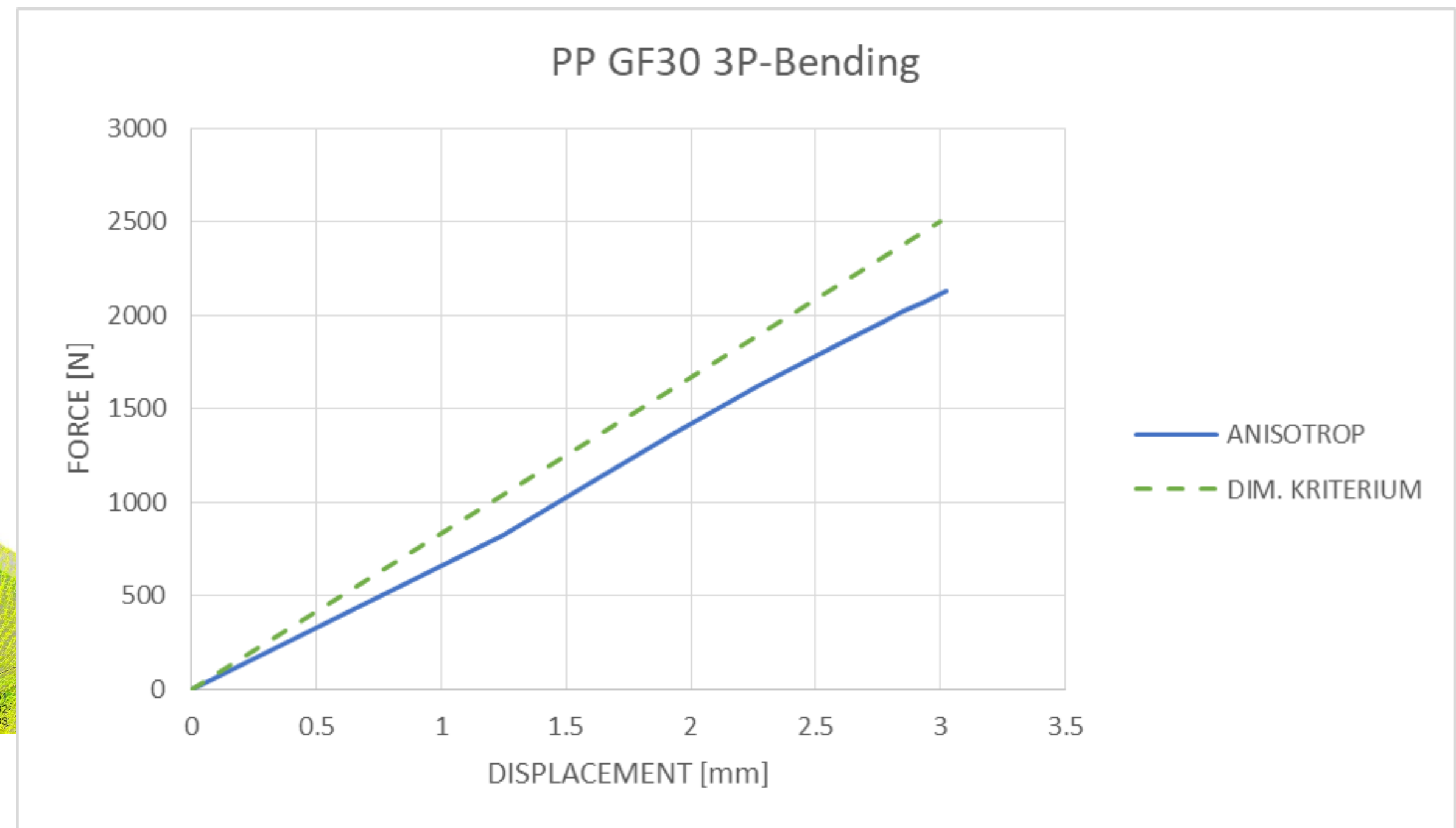
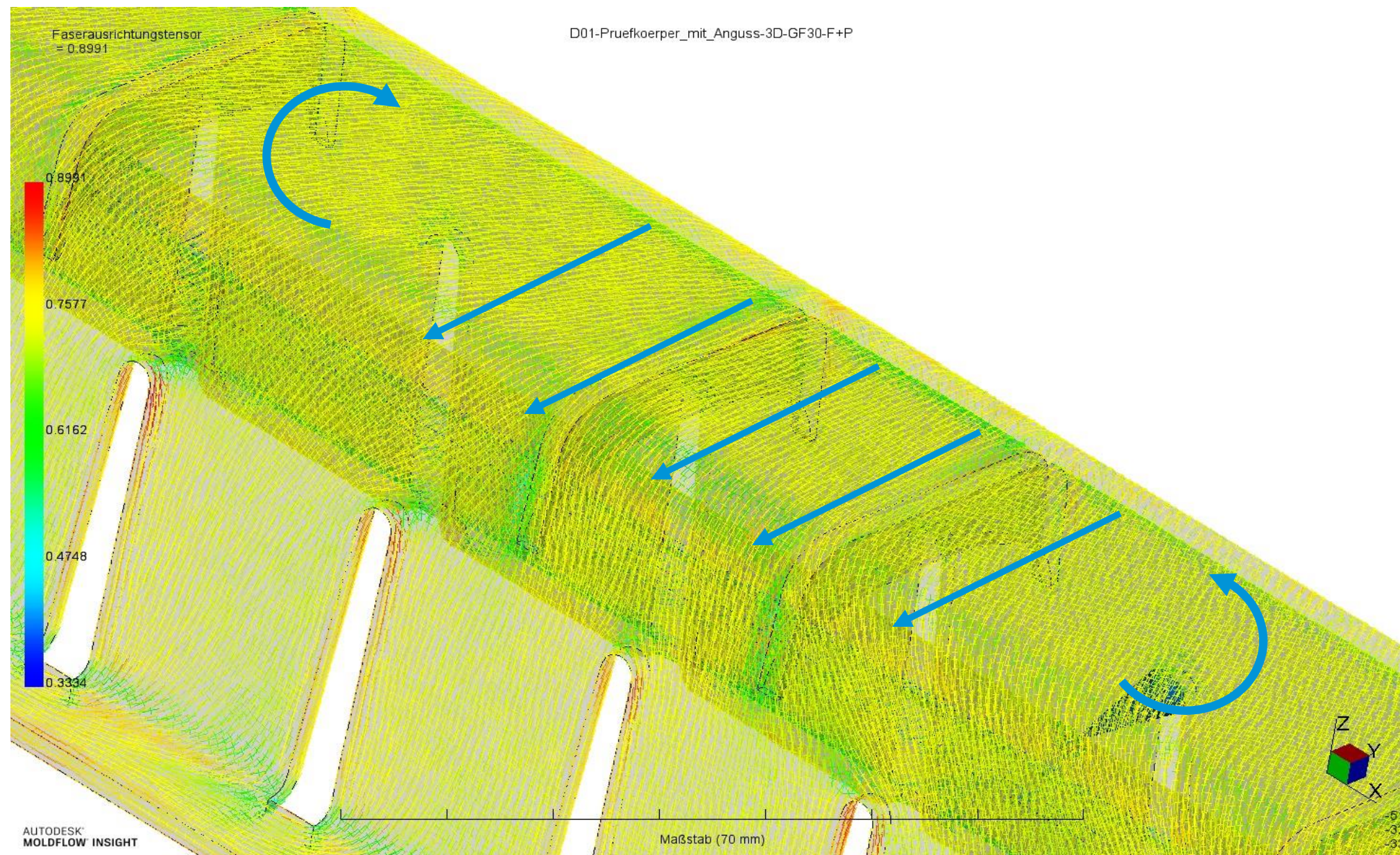
## ➤ Dimensioning Criterion not Satisfied





# Reason for Compliant Part Behavior

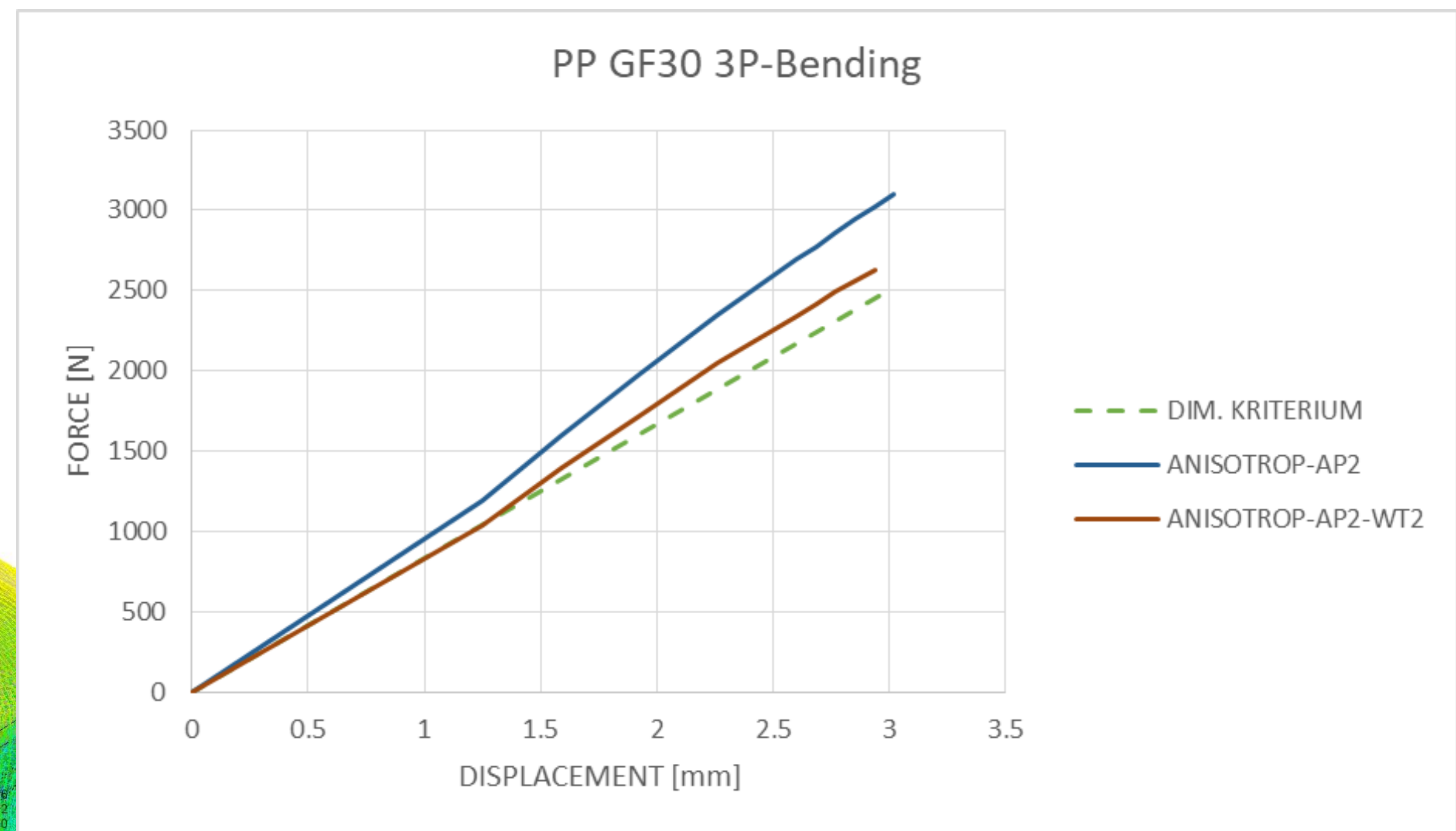
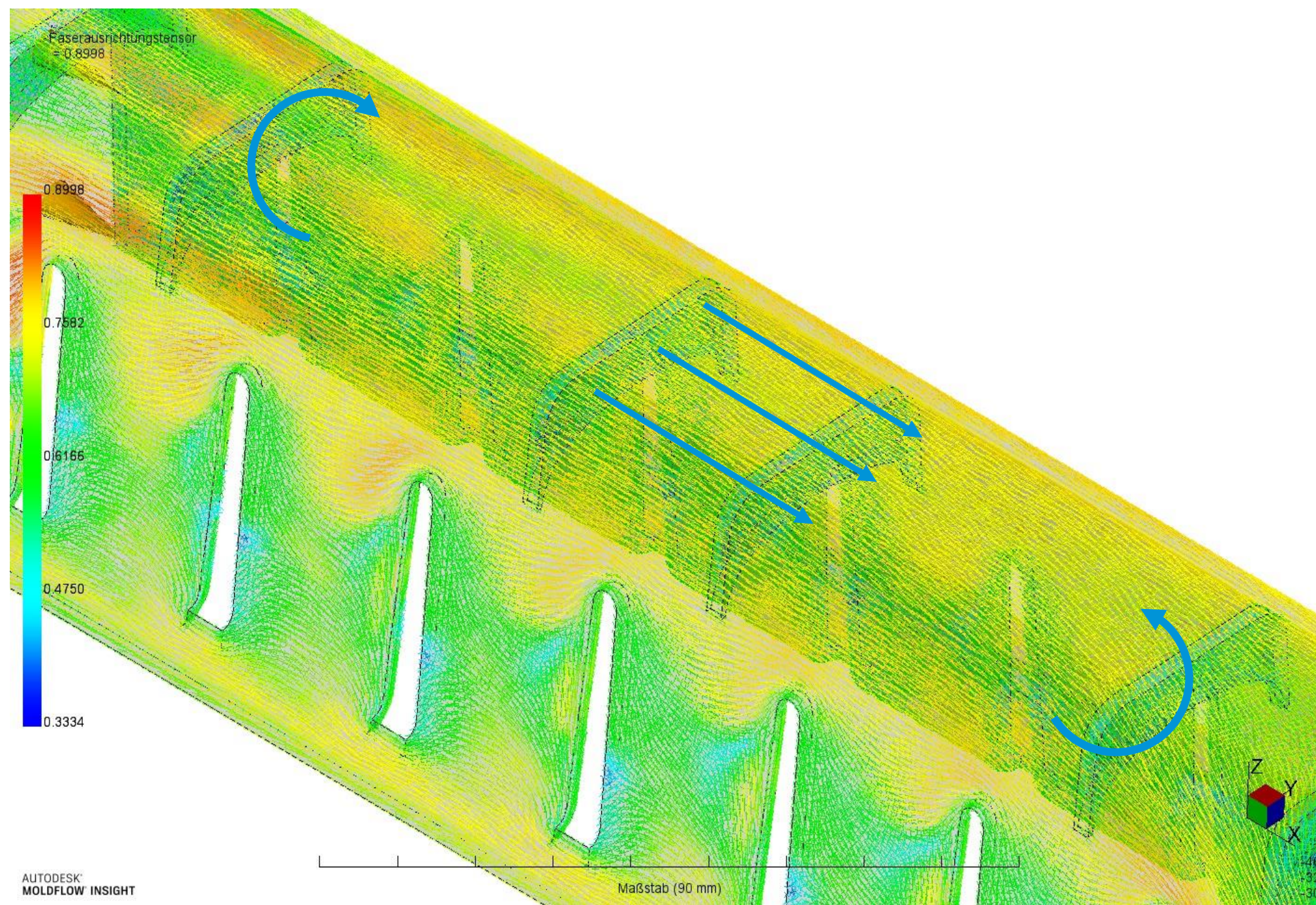
- Resulting Fiber Orientation is Unfavourable for the Load Case





# Optimization

- Change of Injection Location
- Reduction of Wall Thickness (2,5 mm → 2 mm)





# Optimization


- Modification Loop of Mold 30.000 €
- Injection Point Optimization Provided Lightweight Potential:
  - material saving 22 g / 21%
  - savings per part 0,044 €
  - savings per year 22.000 €
- Reduced Wall Thickness Reduces Cycle Time:
  - cycle time saving 6 s / 15,8 %
  - savings per part 0,058 €
  - savings per year 29.200 €
- Saving 1. Year 81.200 €
- Saving 5 Years Tool Lifetime 286.000 €
- 10 Tools / Year 2.860.000 €








# Summary & Conclusion


- The classical approach can not give the engineer save and reliable information about part behaviour resulting from the manufacturing process.
- The integrative simulation always yields more information about the part behaviour.
- The integrative simulation workflow can be used in early design stages with little more effort than the classical workflow.
- Lightweight potential can be discovered and utilized to increase profit significantly.


  
Open

  
Part Mapping

  
Start Here

  
Tutorials

  
Videos

  
Help

Launch Information Pairing

Learn

Import Moldflow Model

Import Structural Model



**Many thanks for your attention**

For more information, visit our homepages

<https://www.moldflow.eu/>

<https://www.pe-group.de/>