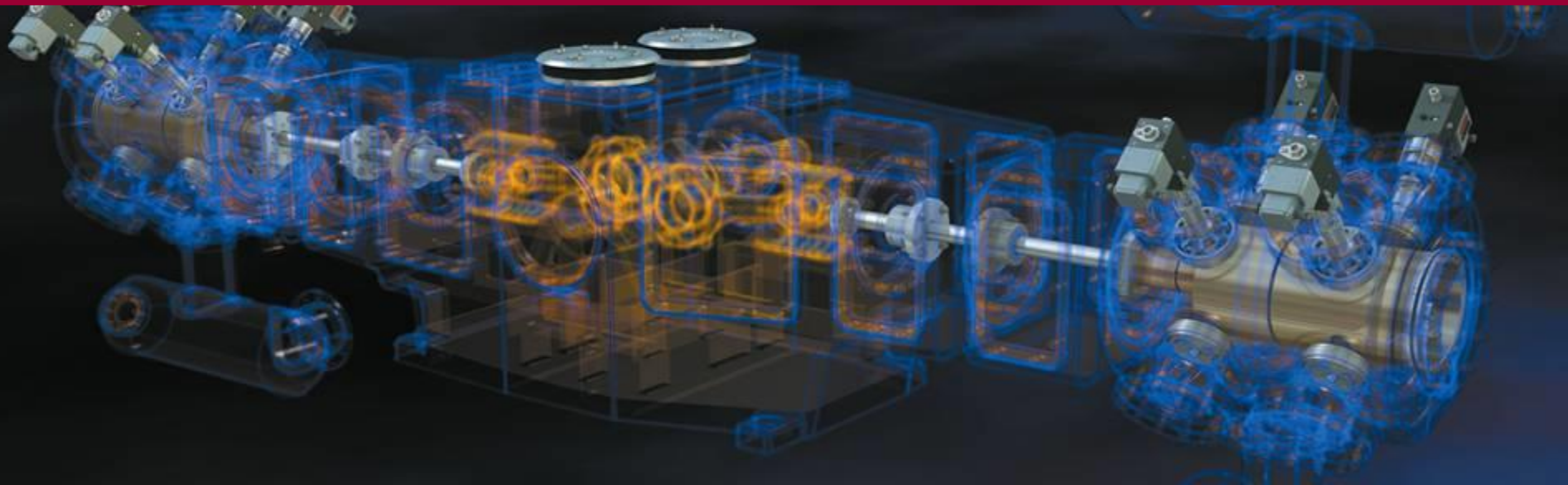


Innovative Approach to increase Weldline Strength in Short Fiber Reinforced Parts

Marian Janko, Bernhard Spiegl, Andreas Kaufmann



Agenda

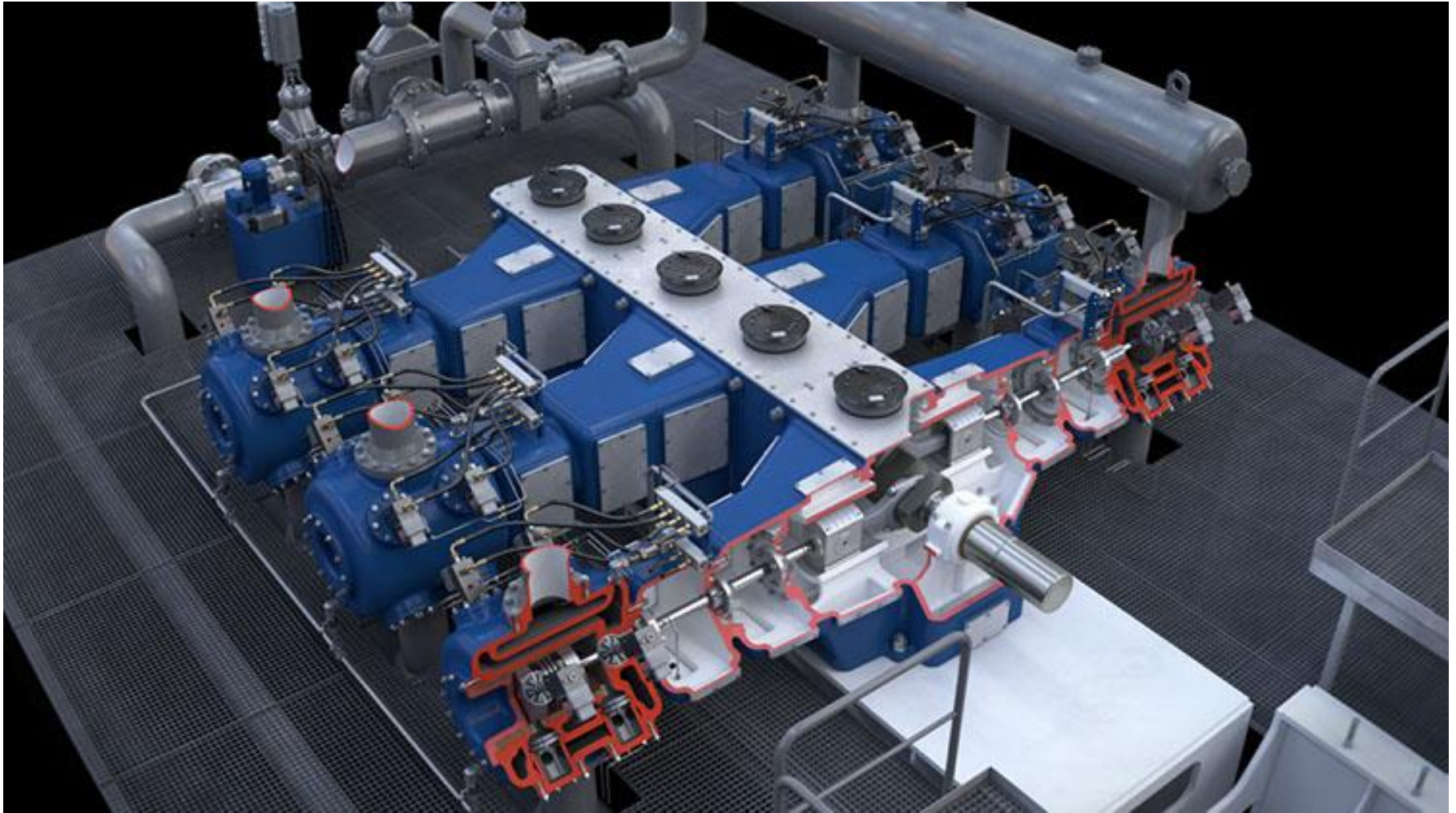
- 1. Introduction**
- 2. Common Improvement Concepts**
- 3. New Concept**
- 4. Measurements**
- 5. Results**
- 6. Simulation**

HOERBIGER

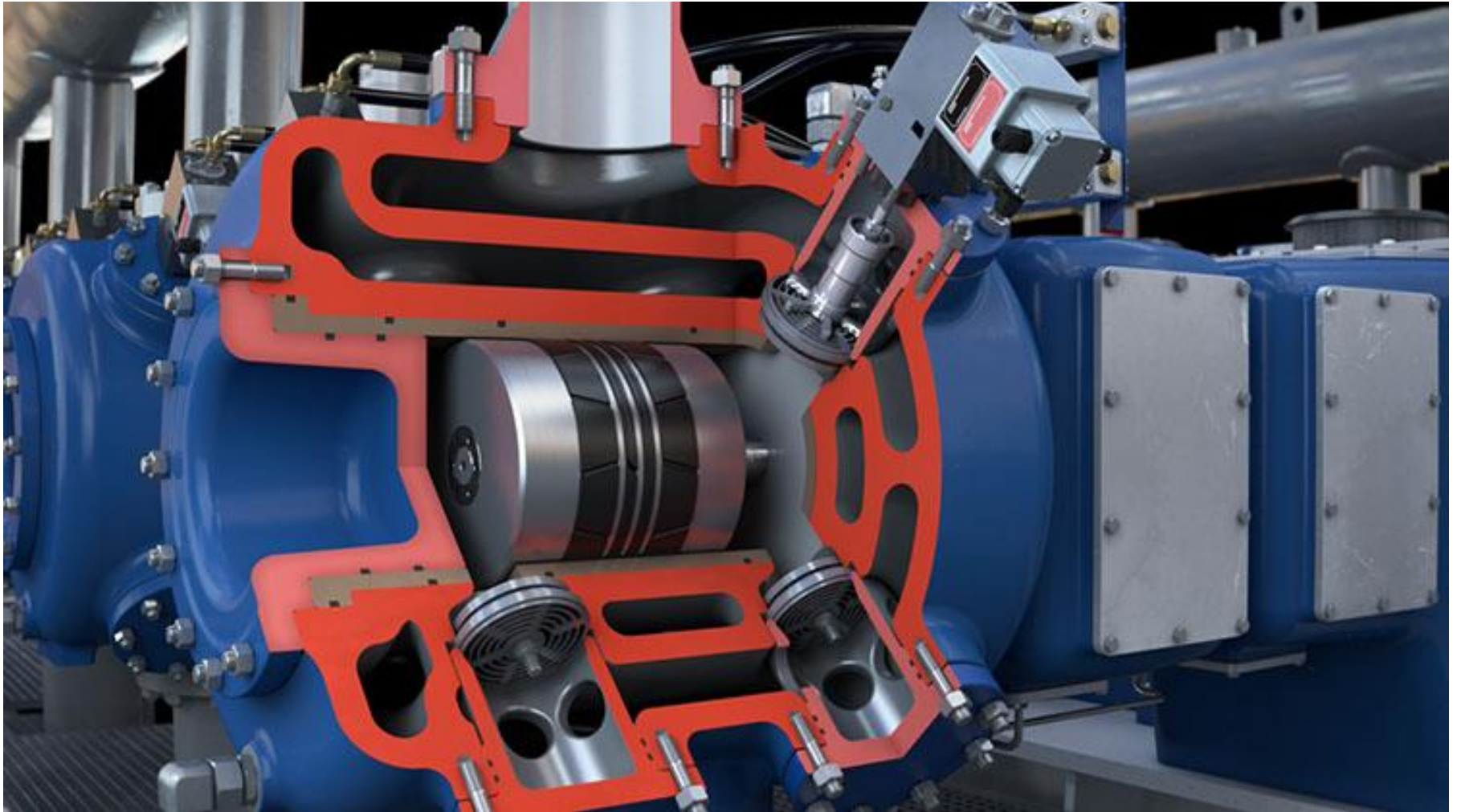
- **Worldwide leading company**
- **130 Production & Service Locations**
- **6700 Employers**
- **~ 1.000 Million EUR revenue**
- **Founder: Hanns Hörbiger**
- **Compressor Solutions**
 - **Compressor Valves**
 - **Rings & Packings**



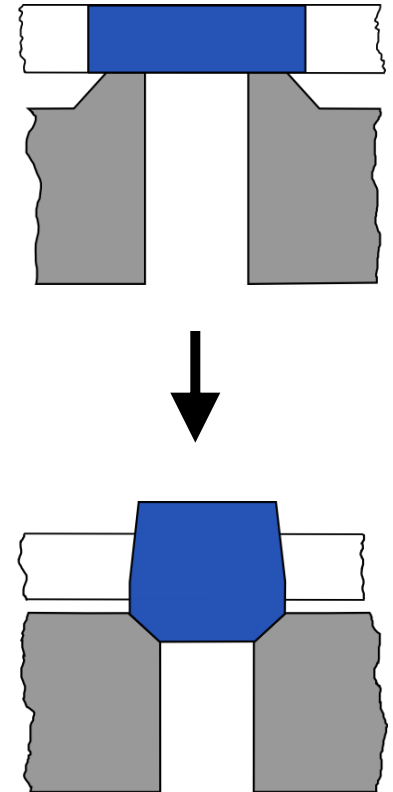
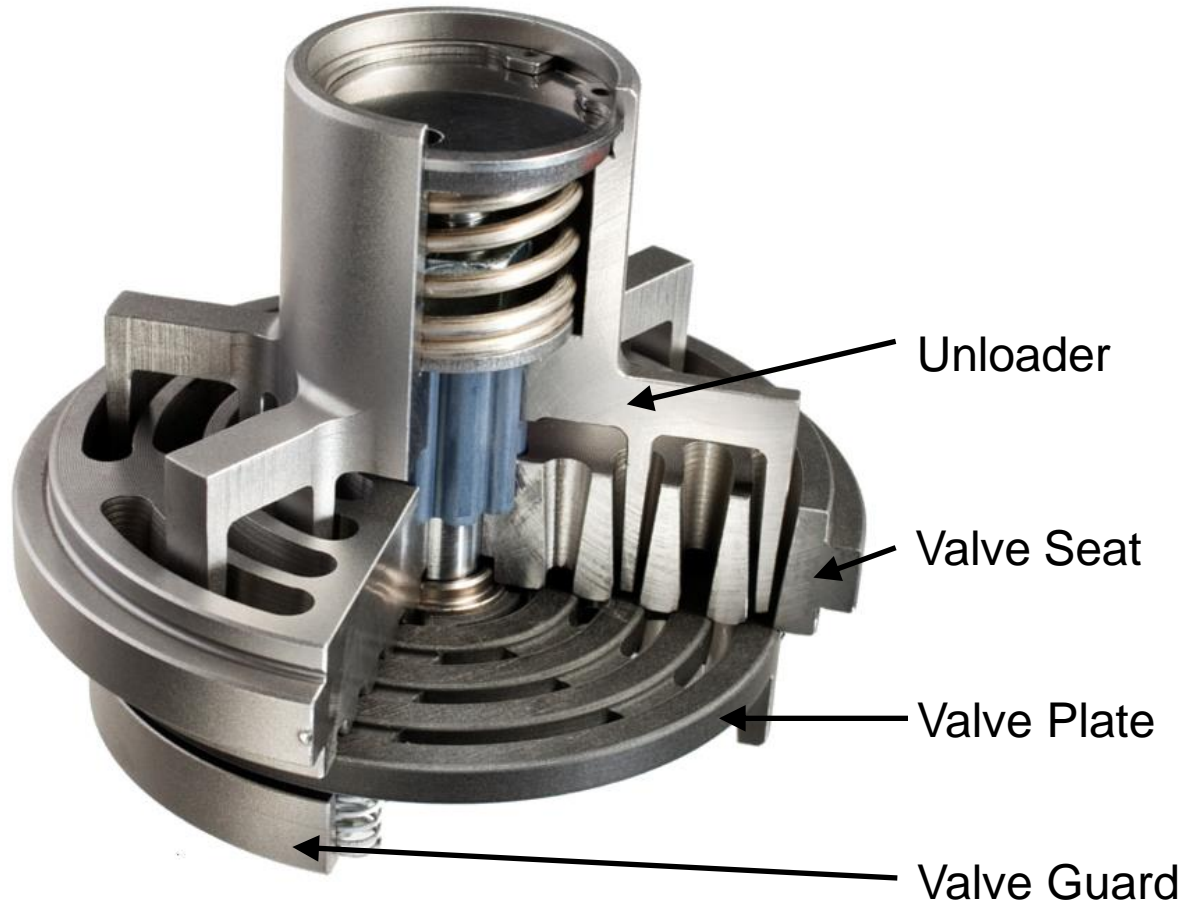
Reciprocating Compressor



Compressor Cylinder and Valves Detail

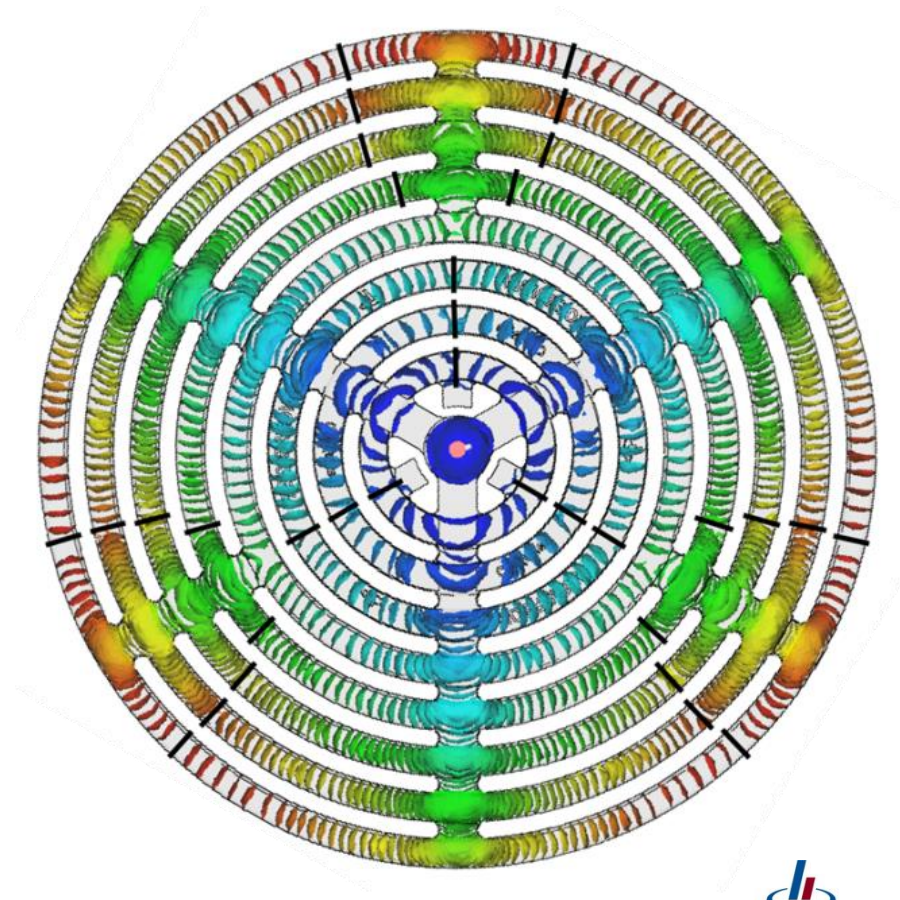
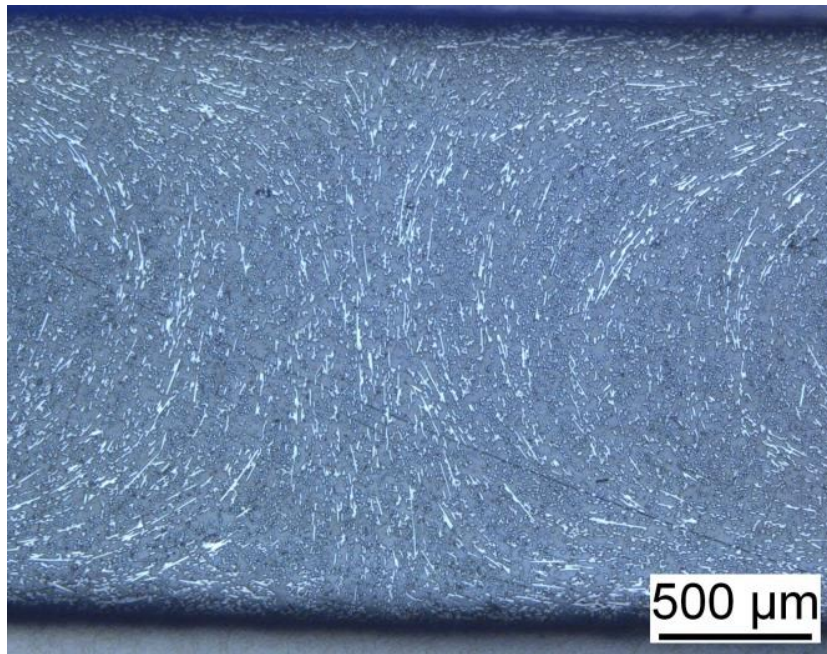


Valve Detail



Weldlines in Next Generation Valves

- Reducing strength of the SFR part
- Fiber orientation



Common Improvement Concepts

- **Push-Pull concept**

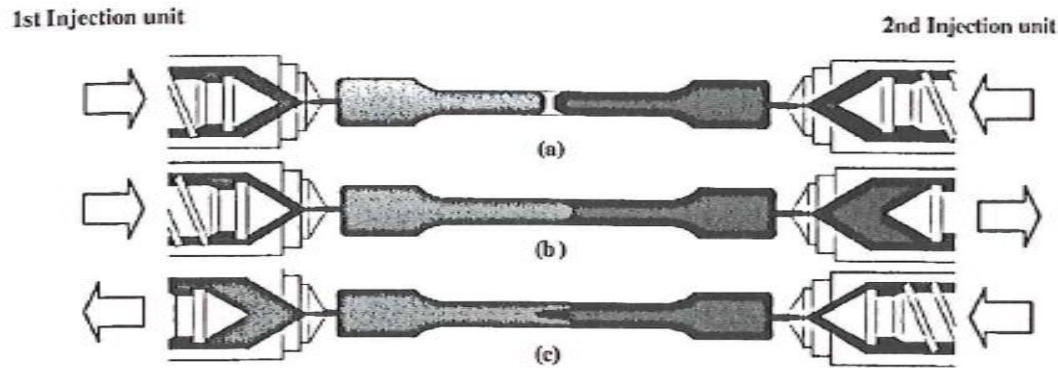


Figure from [1]

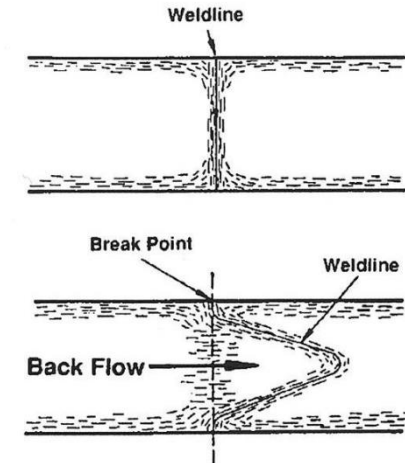


Figure from [2]

- **Side gate concept**

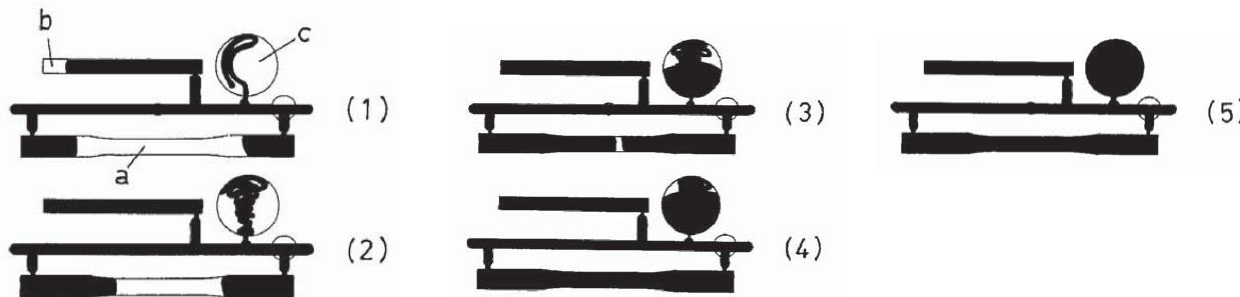


Figure from [3]

- [1] S. Patcharaphun. Journal of Reinforced Plastics and Composites, 25(4):421-435, 2005.
 [2] K. Tomari, H. Takashima, and H. Hamada. Advances in Polymer Technology, 14(1):25-34, 1995.
 [3] H. Hamada, Z. Maekawa, T. Horino, K. Lee, and K. Tomari. Int. Polym. Process, (2):131-136, 1988.

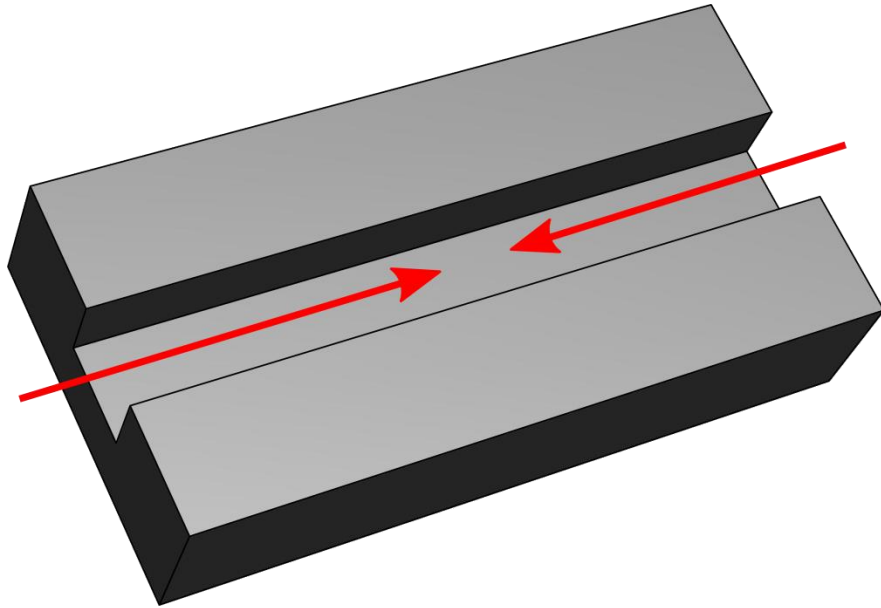
Common Improvement Concepts

- **Optimization of process parameters**
 - Tests on direct molded valve plates
 - DOE parameters
 - Injection rate
 - Holding pressure
 - Mold temperature
 - Melt temperature
 - Results:
 - Worst to best setting → 25 % weldline strength increase

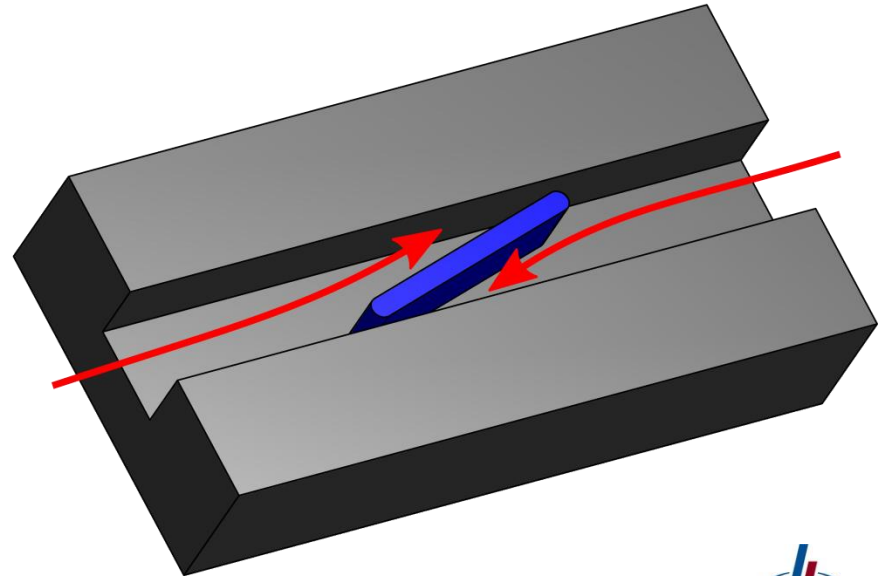
New Concept

- Reorientation of the fibers
- Enlarge the weld 'surface'

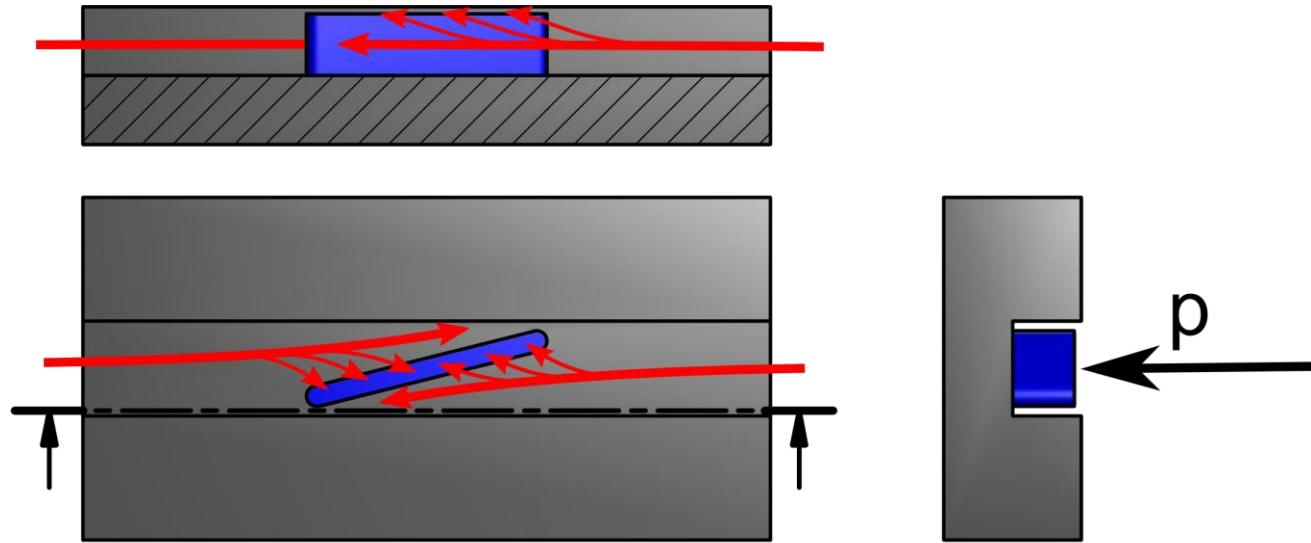
Standard weldline



Obstacle in the weldline area

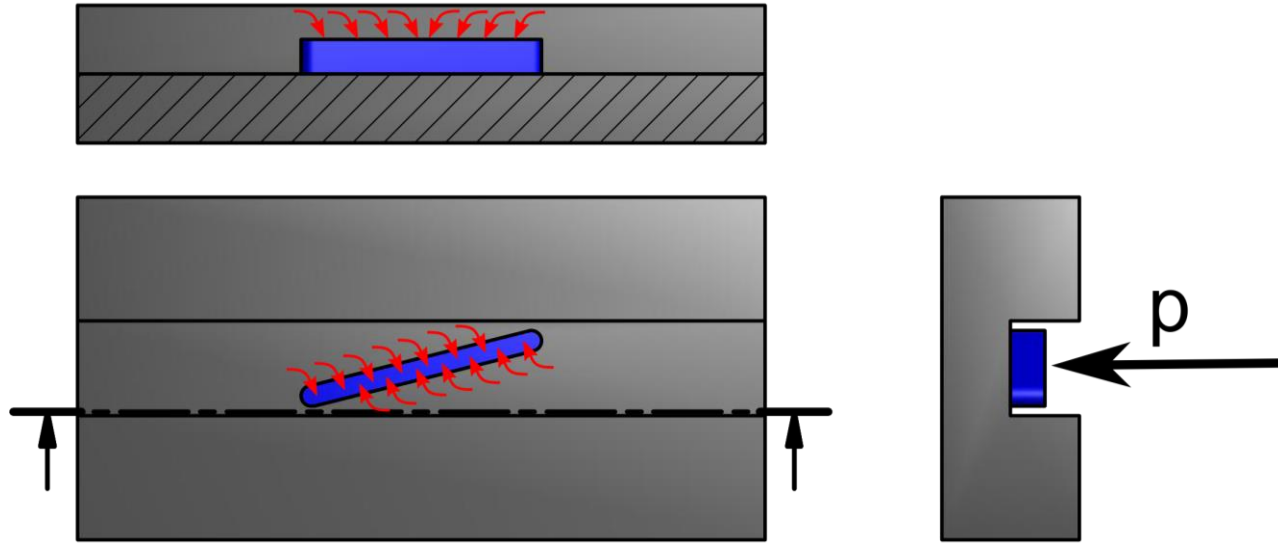


Redirection of the Melt Flow



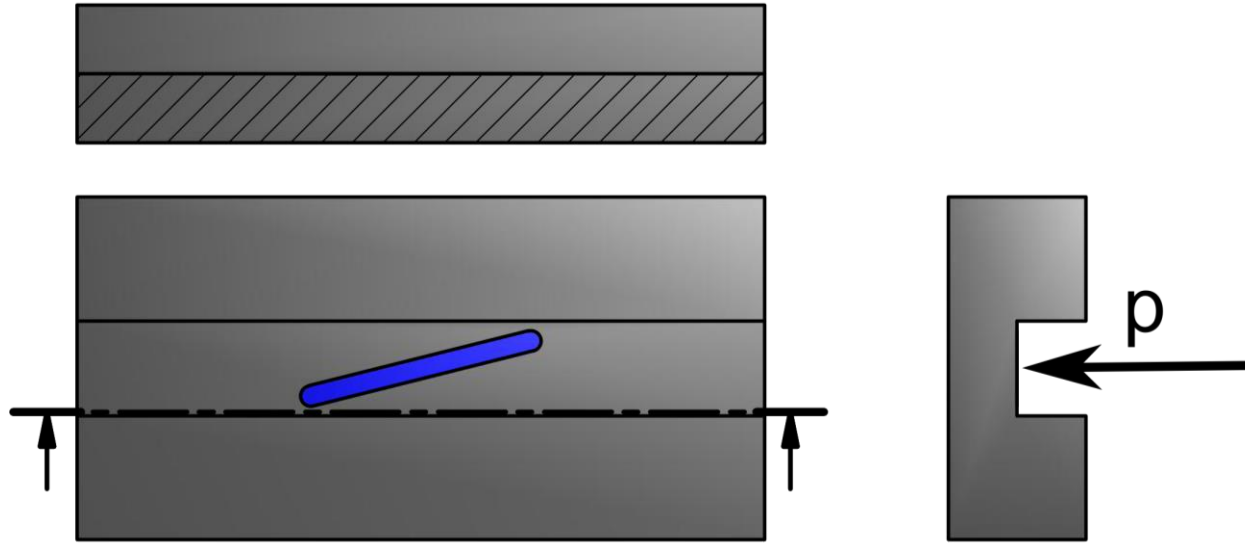
The main melt flow is redirected, with rising melt pressure the small slit between mold surface and obstacle is filled and the pressure p against the moveable obstacle rises.

Moveable obstacle is pushed out



Due to the melt pressure the moveable obstacle is pushed out of the cavity.

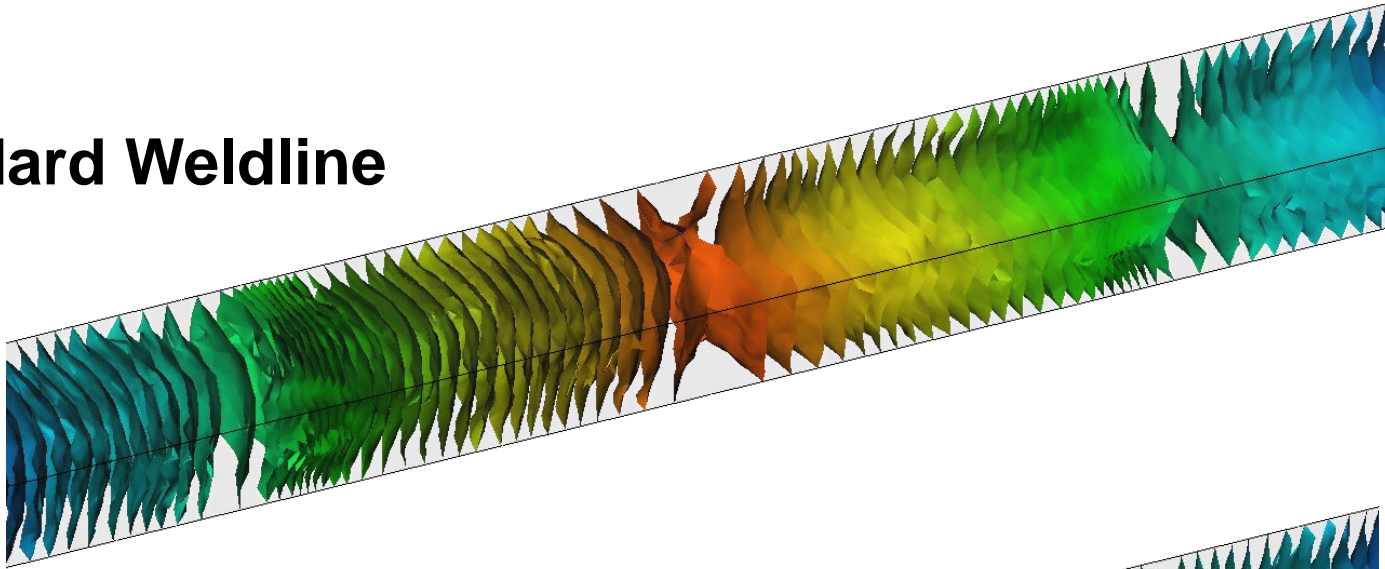
Cavity is completely filled



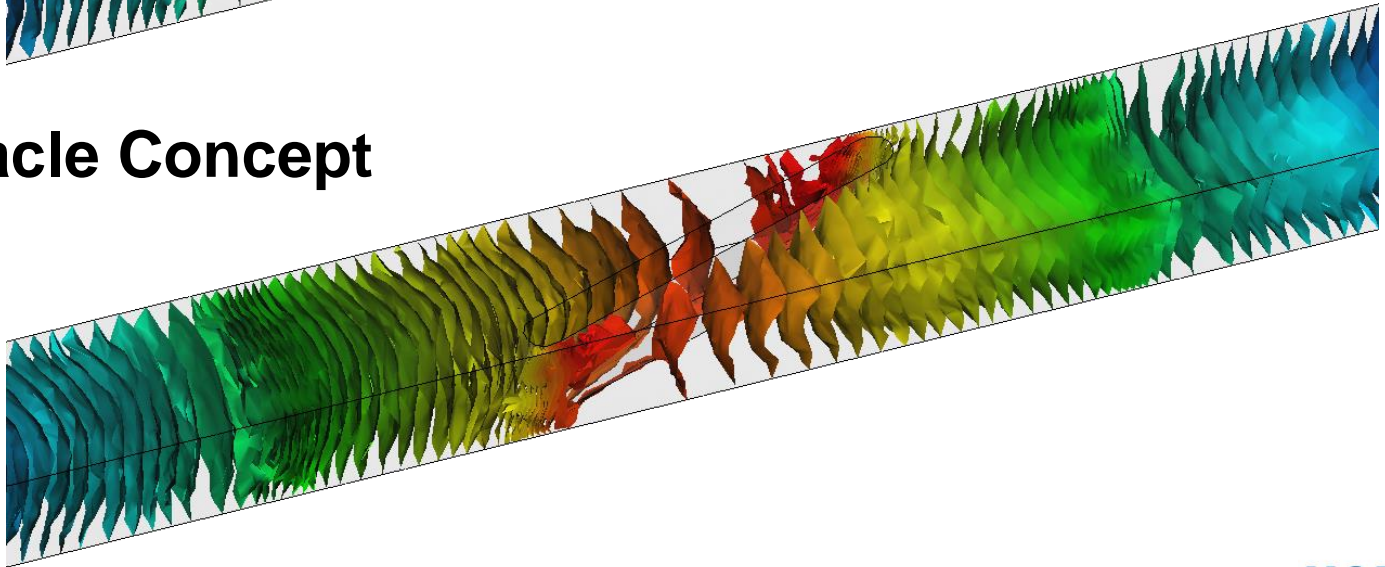
At the end of the movement the obstacle has completely vanished into the mold surface, and the whole cavity is filled with polymer.

Simulation - Moldflow

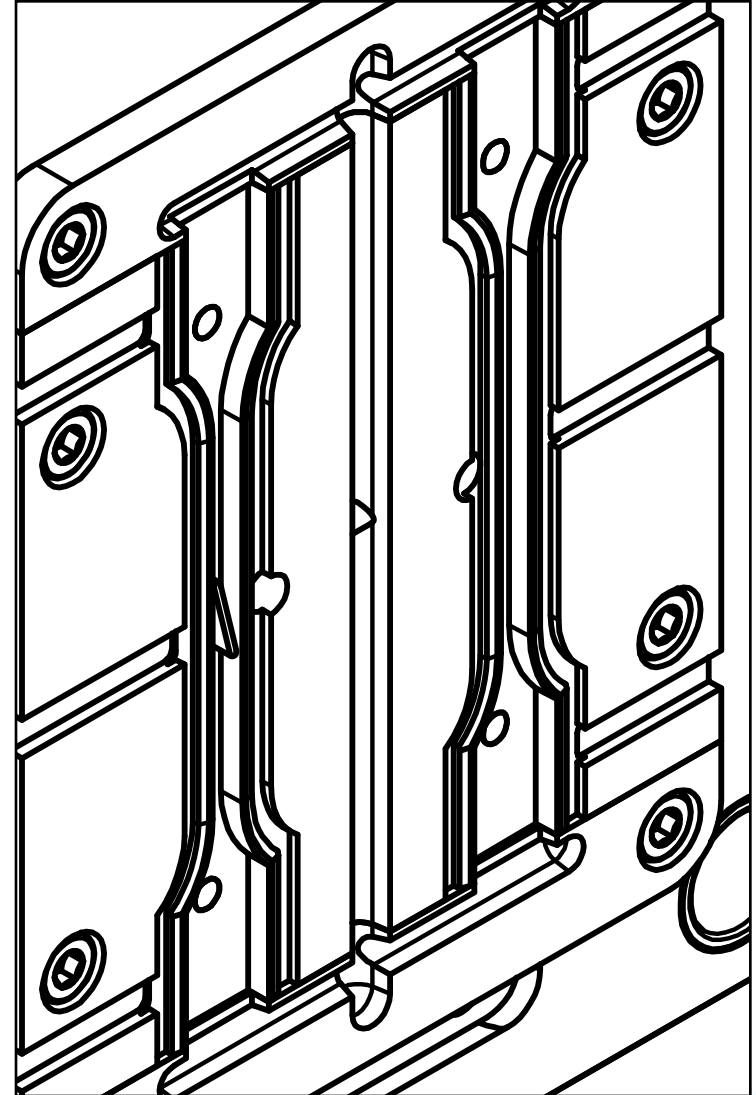
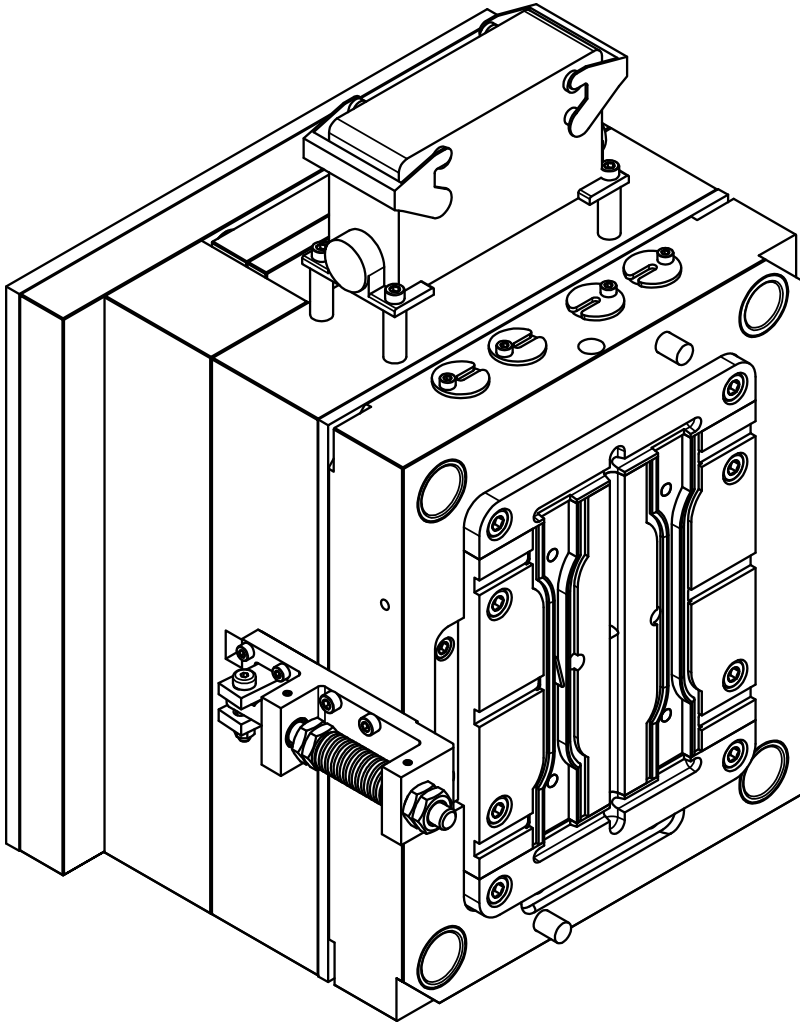
Standard Weldline



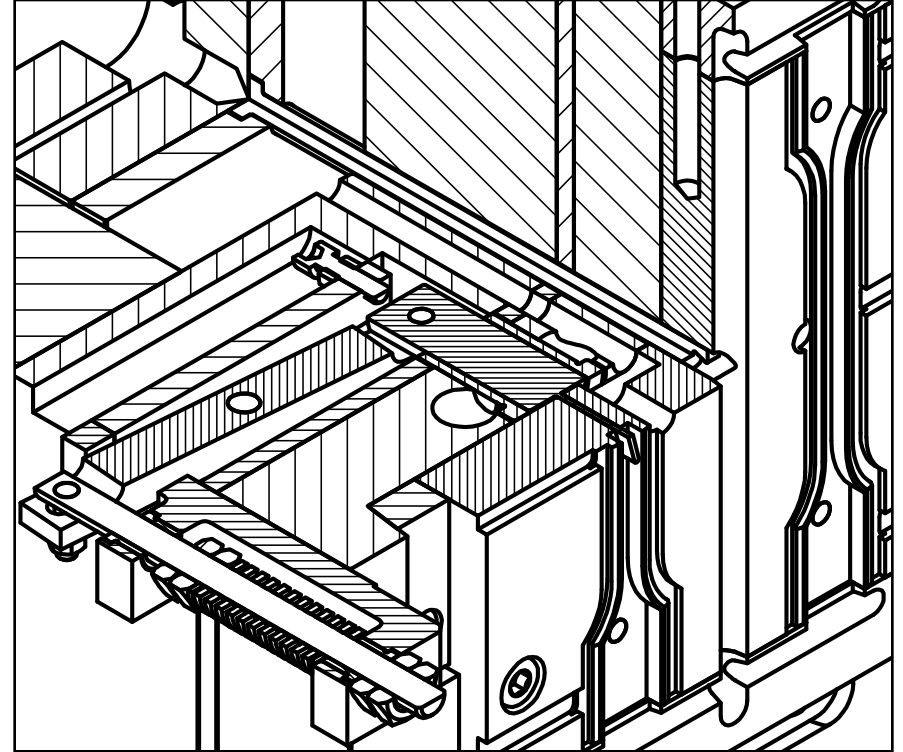
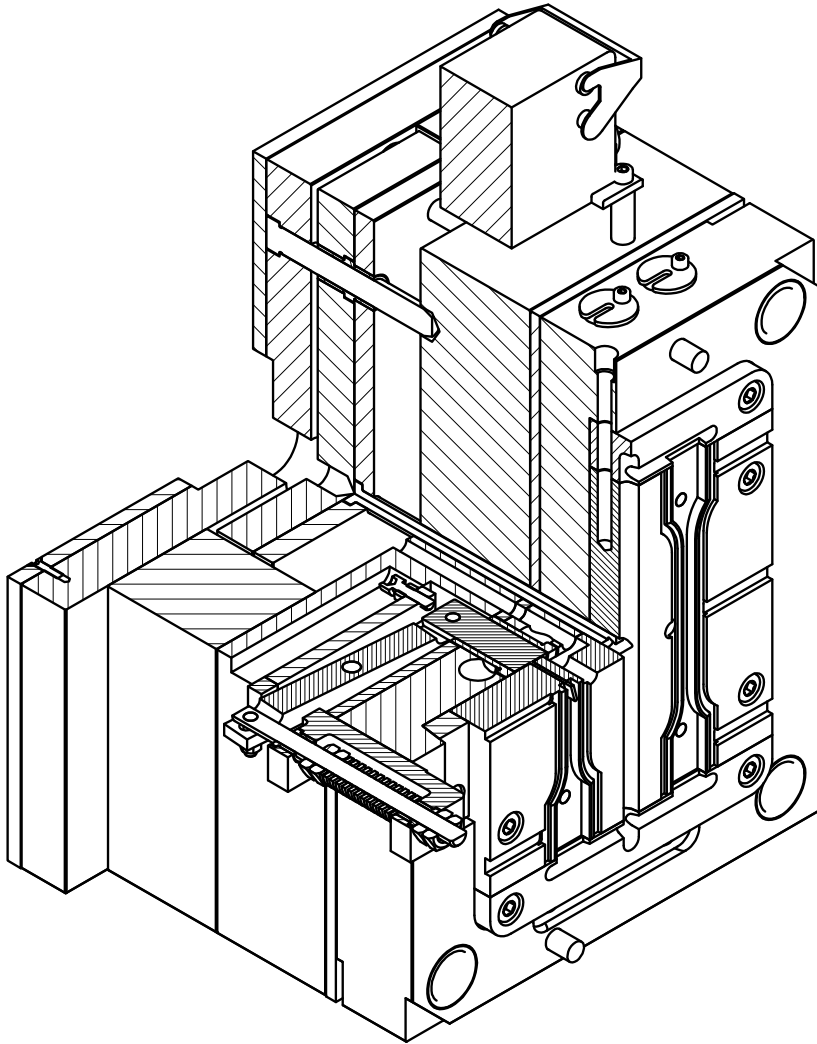
Obstacle Concept



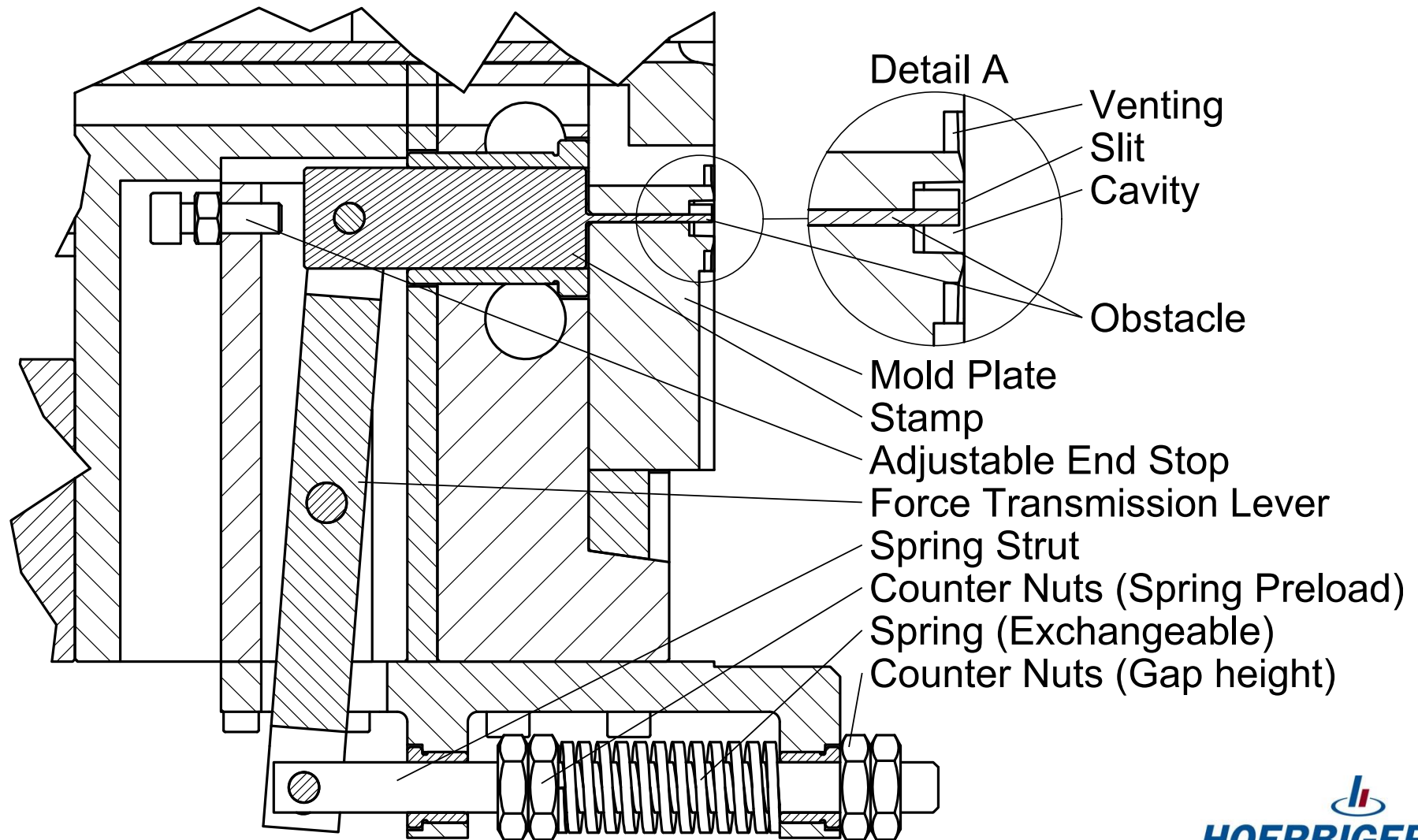
Mold Concept



Mold Concept



Mold Concept



Injection Settings

Material: PEEK CF20

Melt Temperature: 415 °C

Mold Temperature: 190 °C

Injection Rate: 15 cm³/s



Injection Molding - Filling Study

Standard Weldline



a_1



a_2



a_3



a_4

Modified Weldline



b_1



b_2

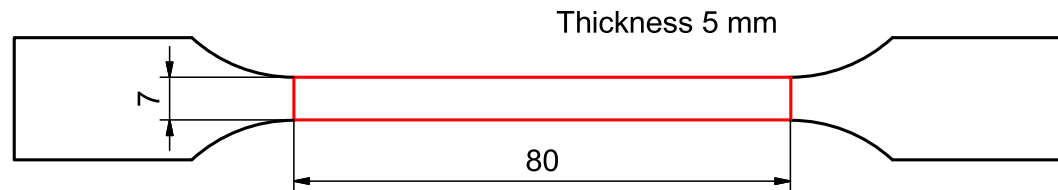


b_3

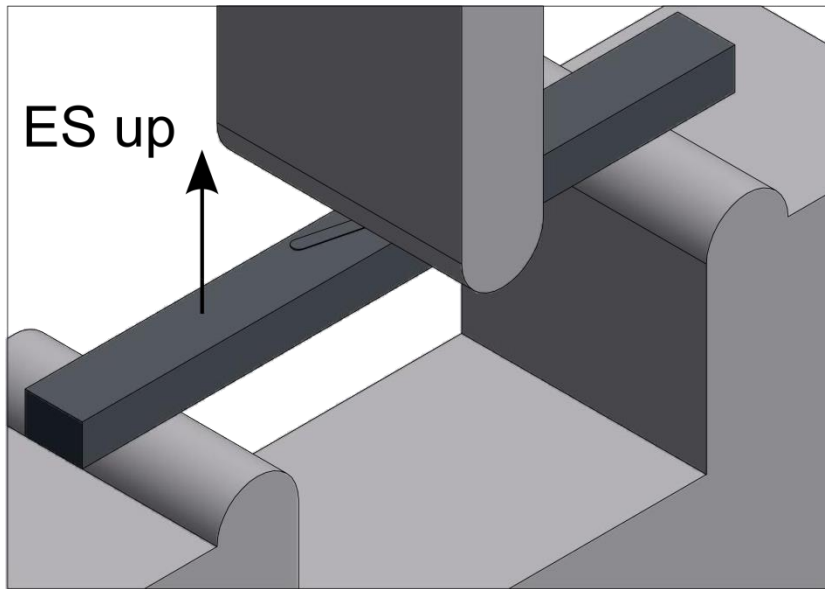


b_4

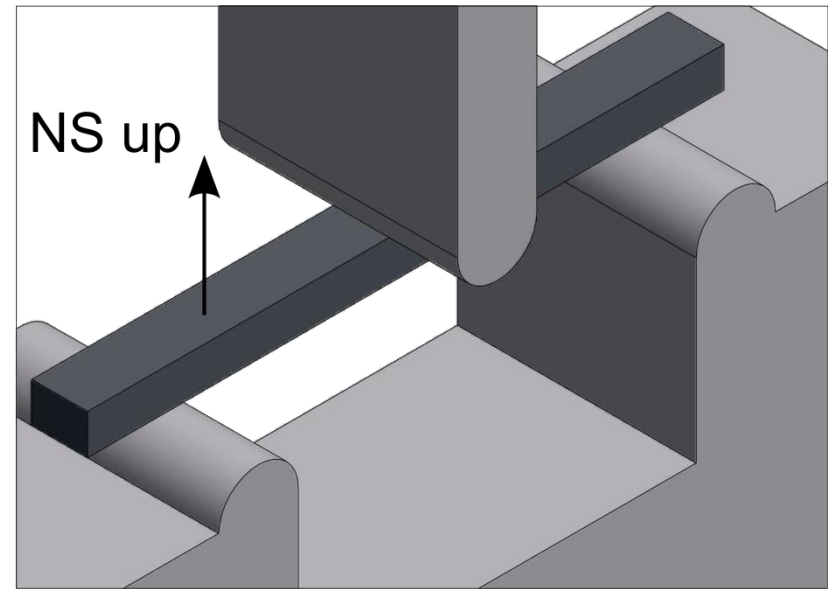
Test Setting - 3 Point Bending



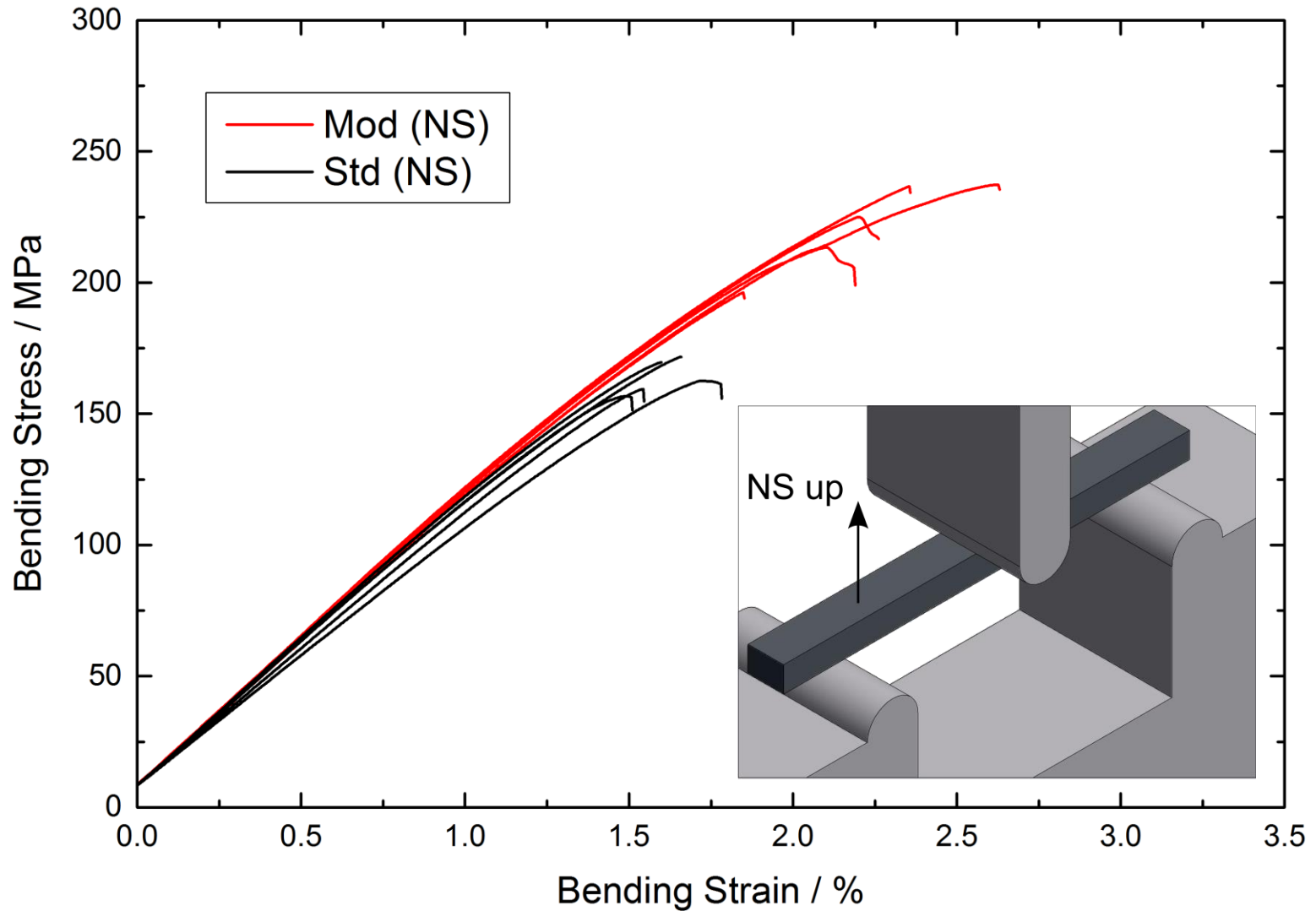
Ejection side up (ES)



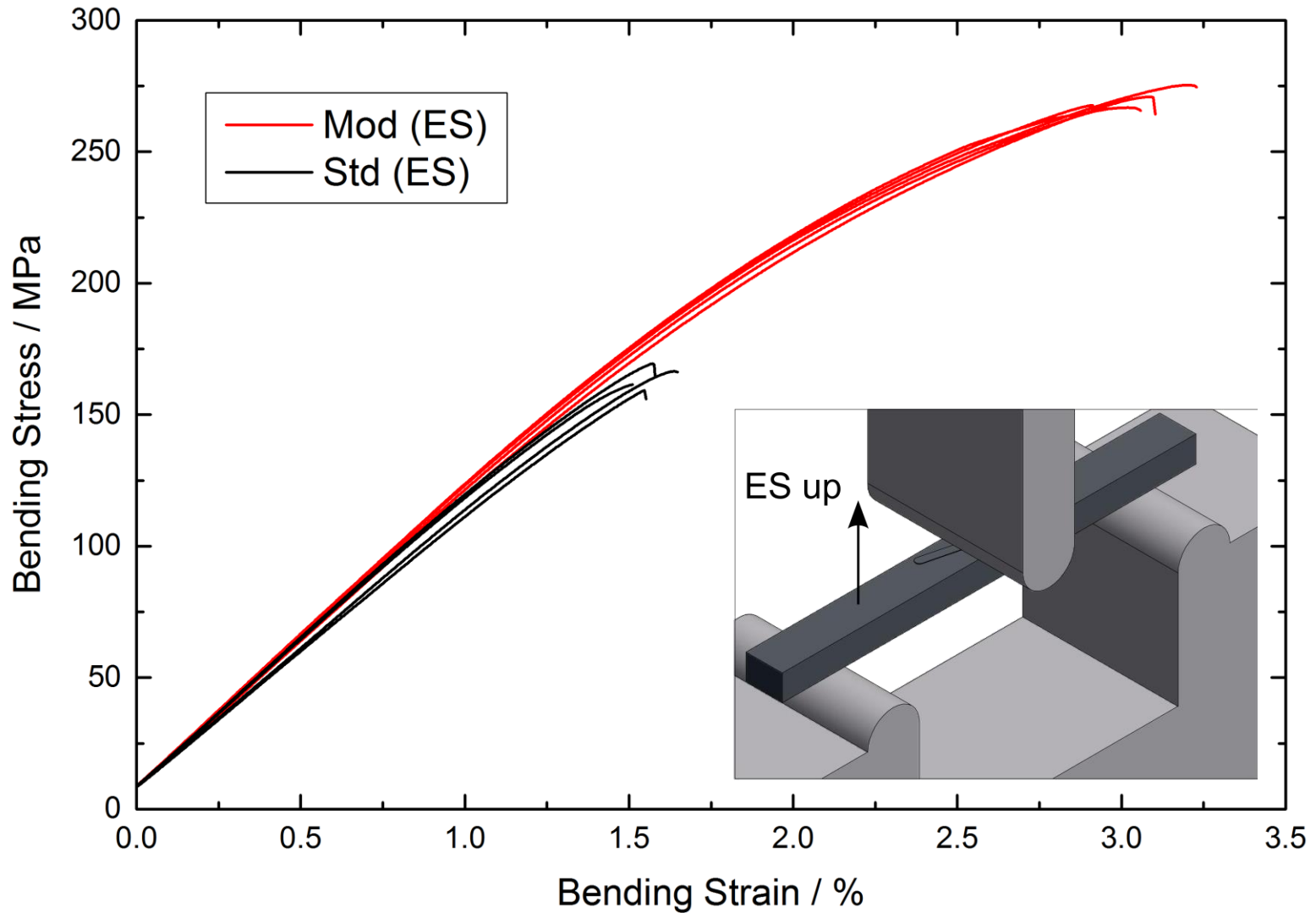
Nozzle side up (NS)



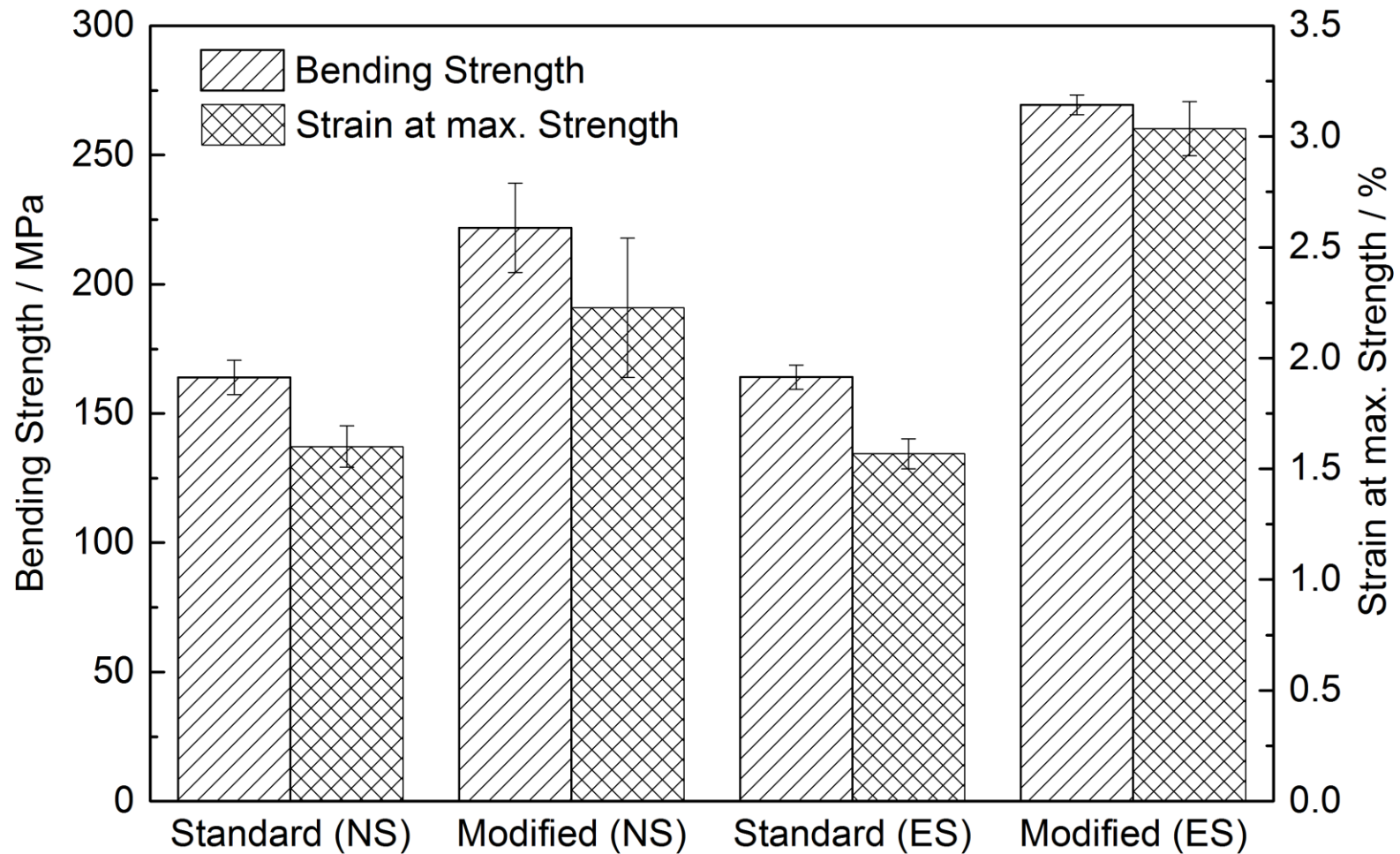
Stress - Strain (NS)



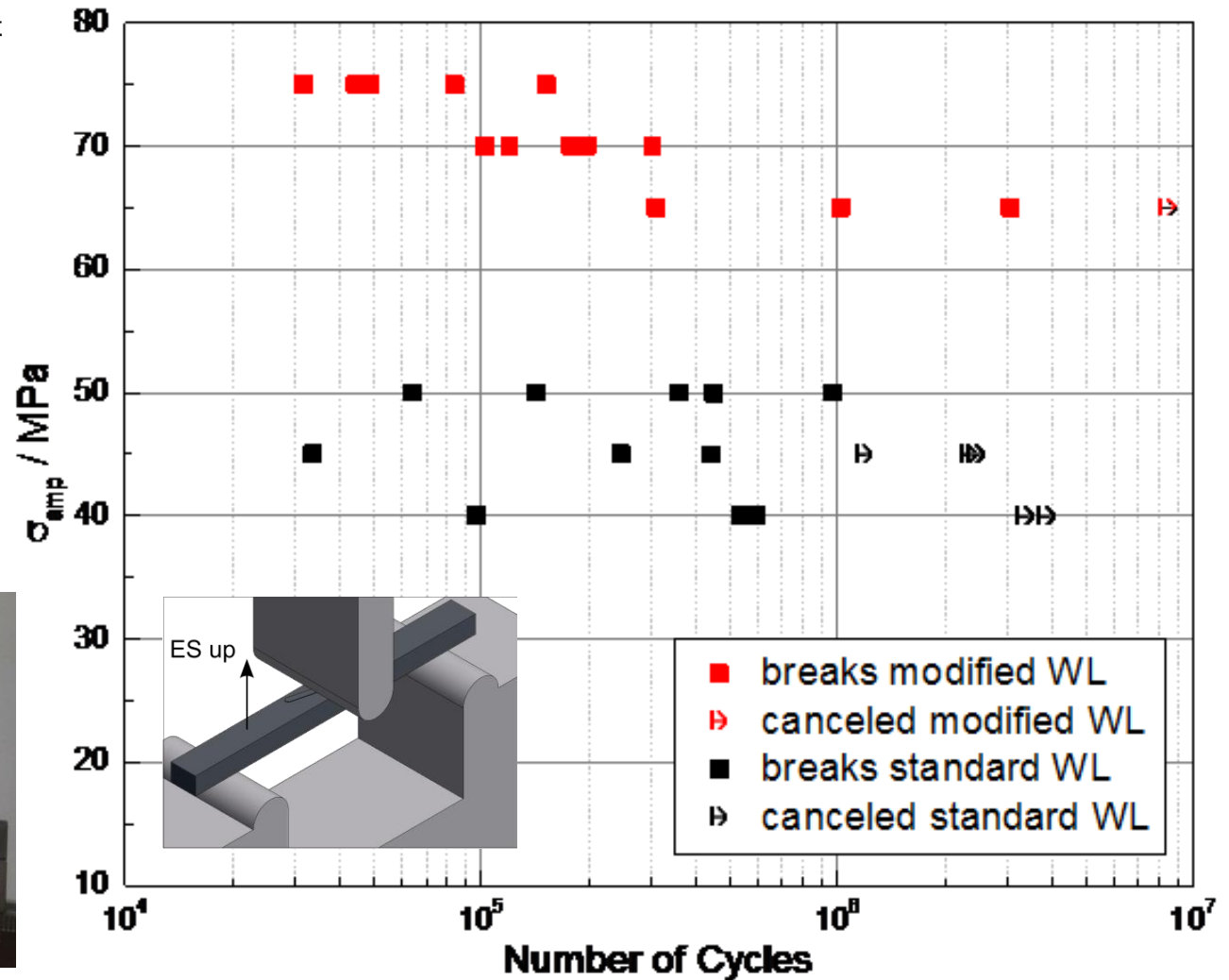
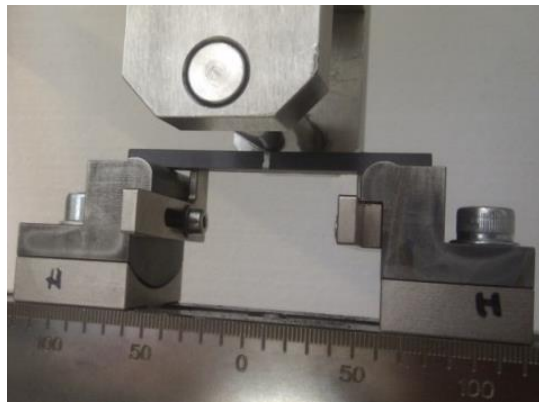
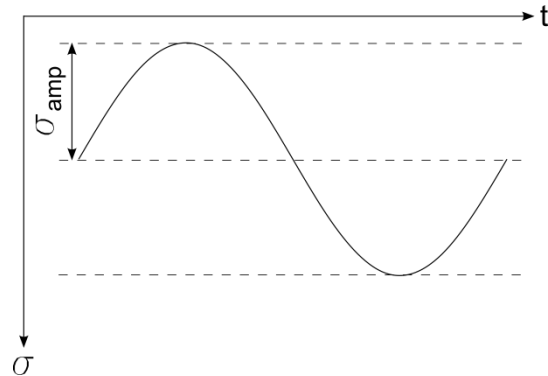
Stress - Strain (ES)



Bar Chart Bending Strength and Strain

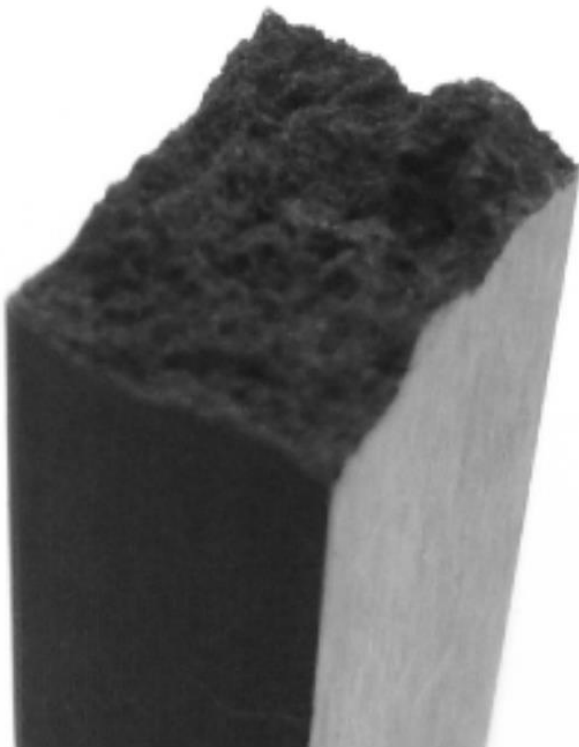


Fatigue Bending Test

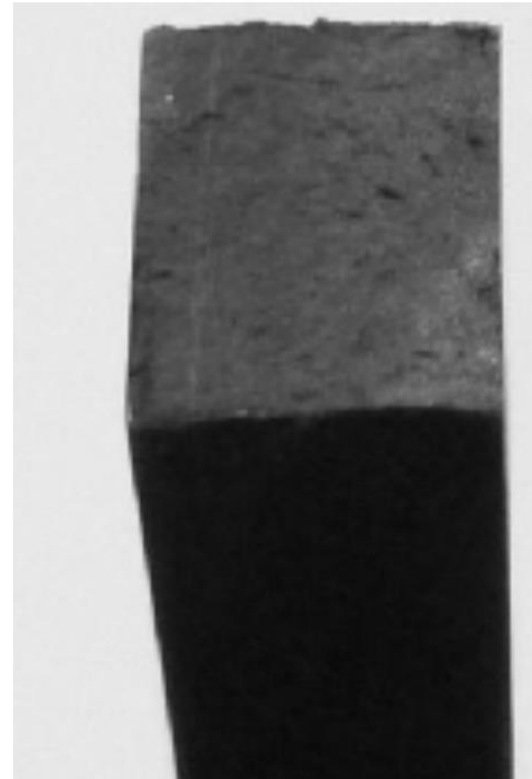


Fracture Surfaces - Standard Weldline

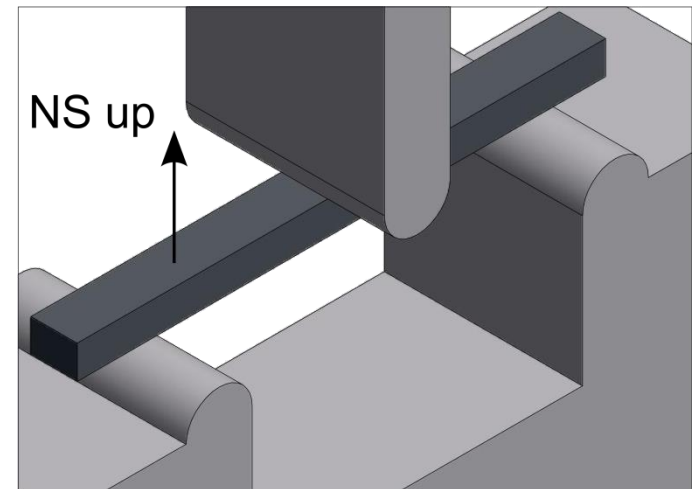
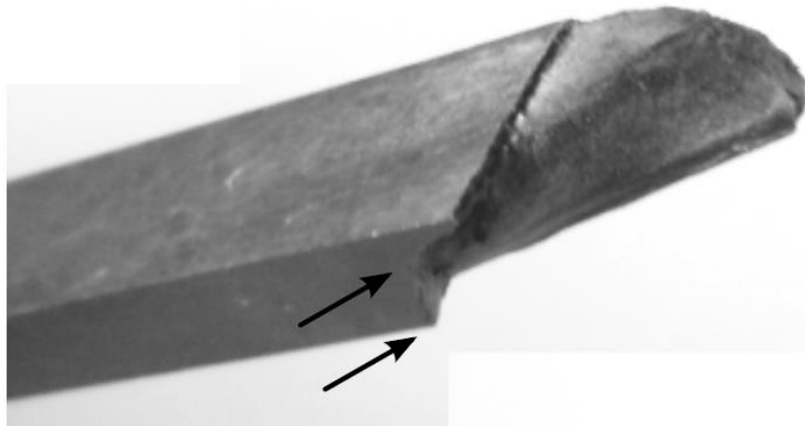
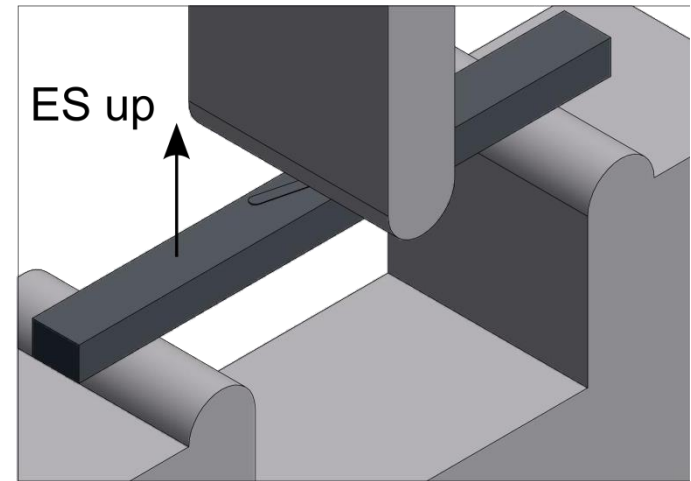
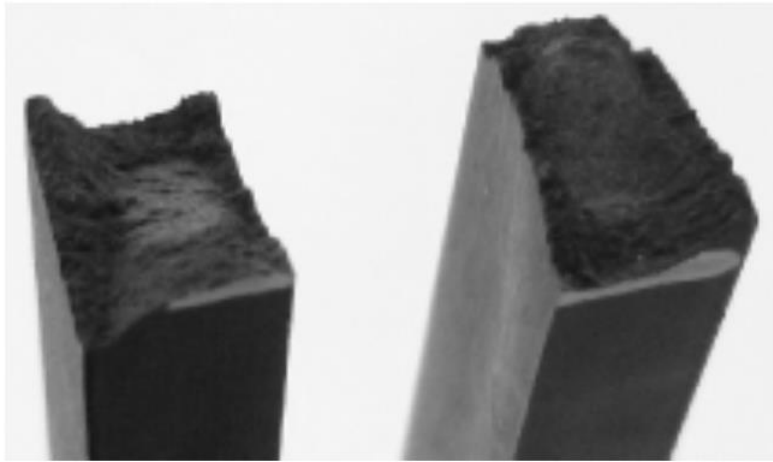
Without Weldline



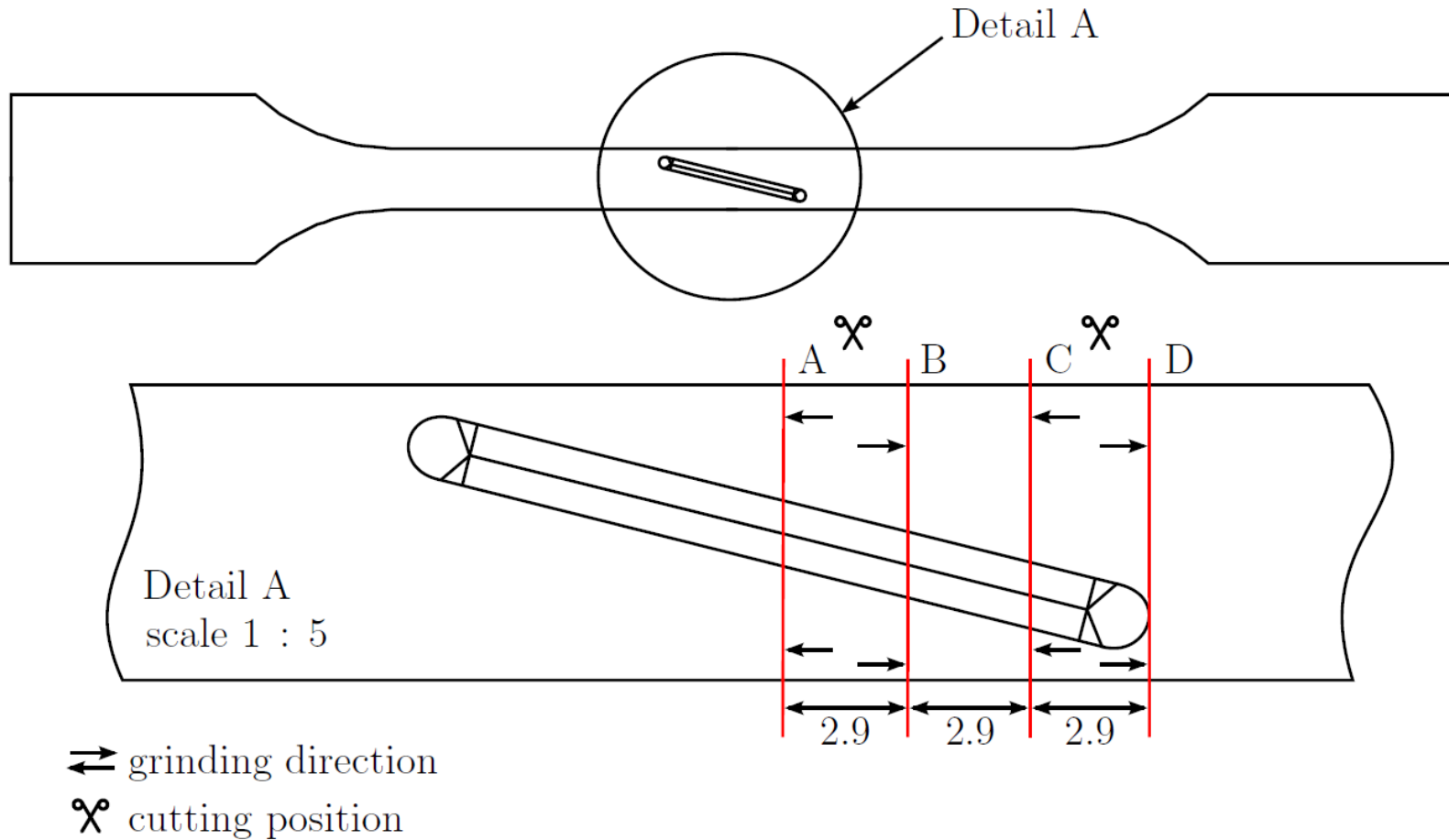
Standard Weldline



Fracture Surfaces - Modified Weldline

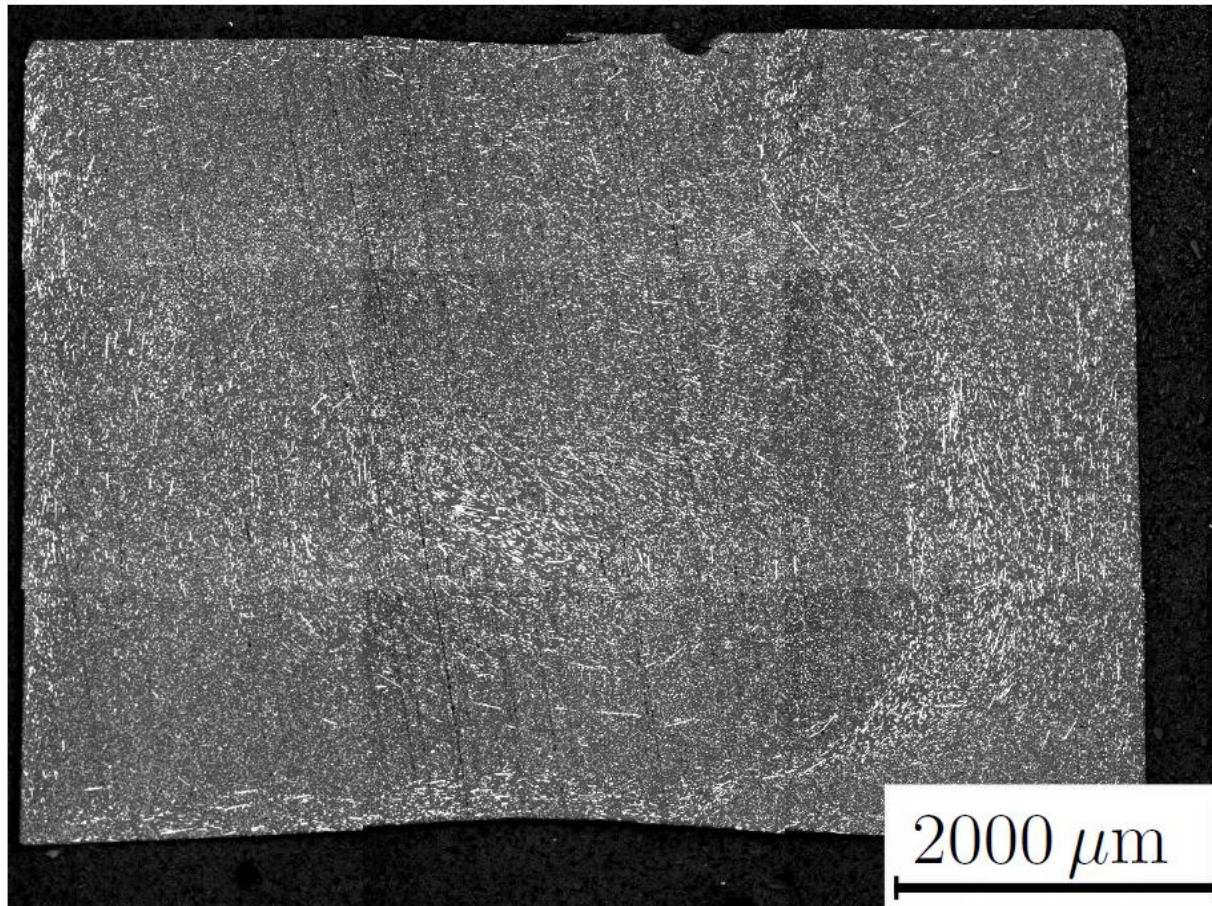


Microscopy of the Modified Weldline Area



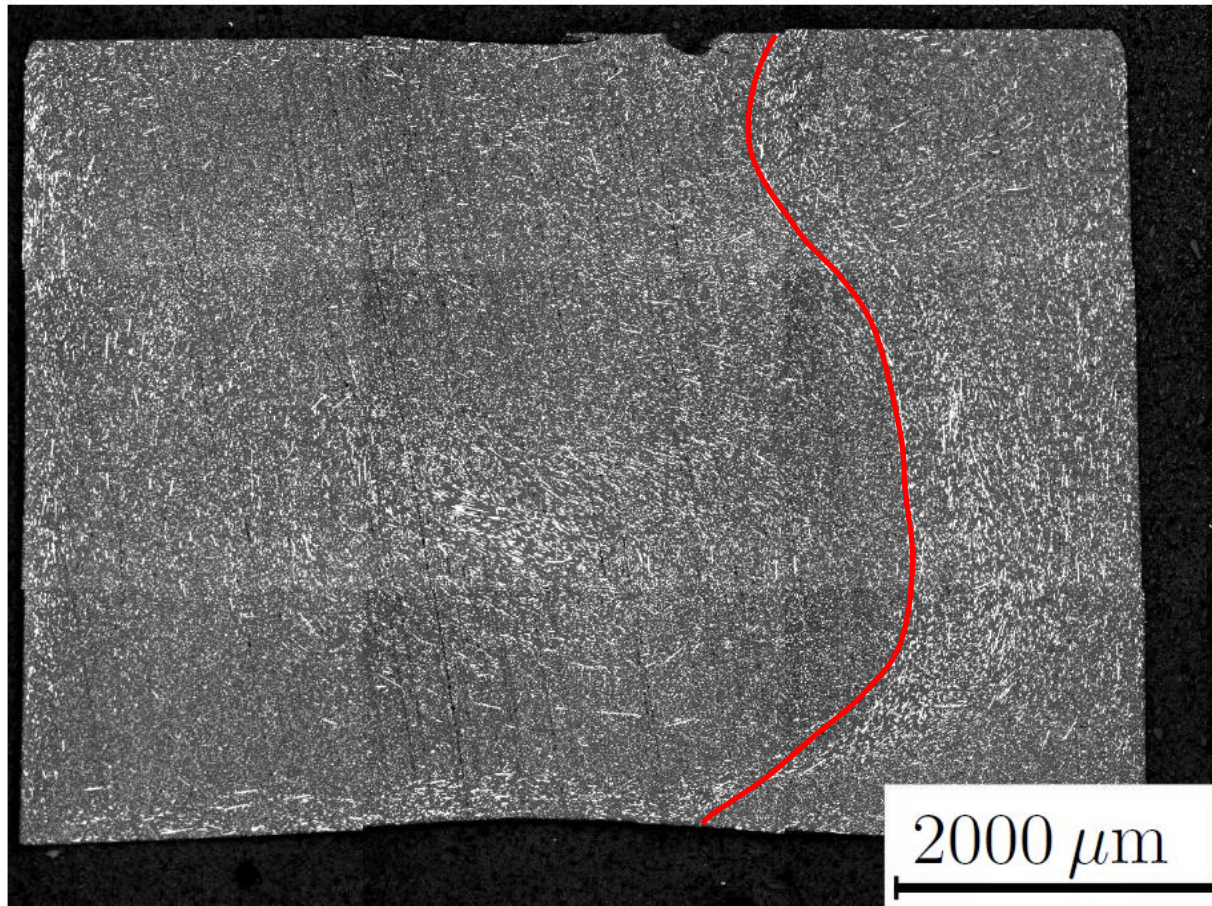
Polishes of the Modified Weldline Area

A₃ (3.17 mm from the middle)

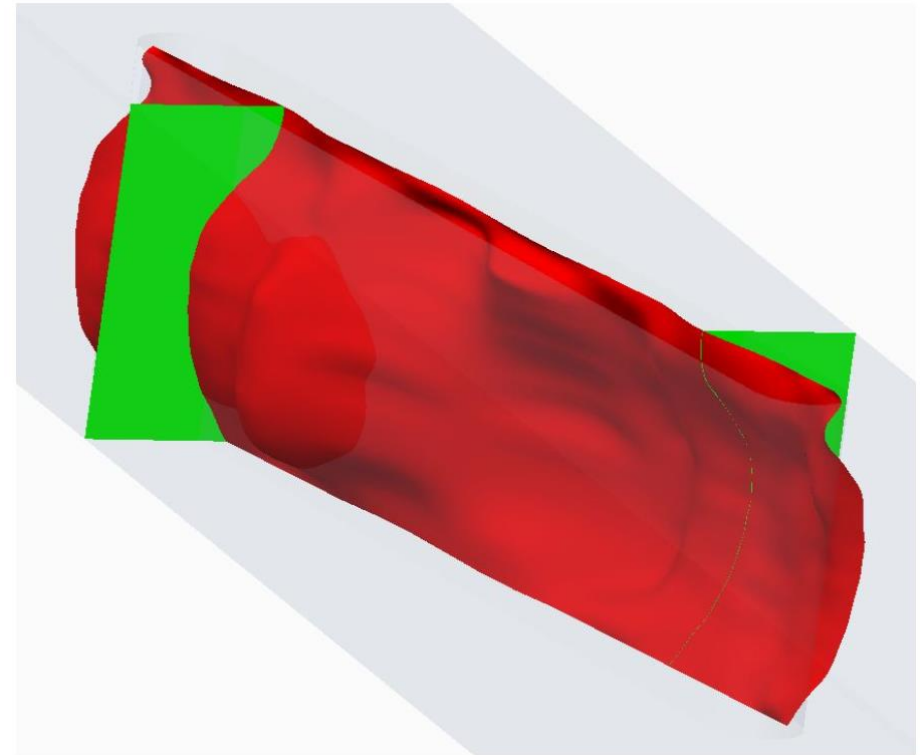
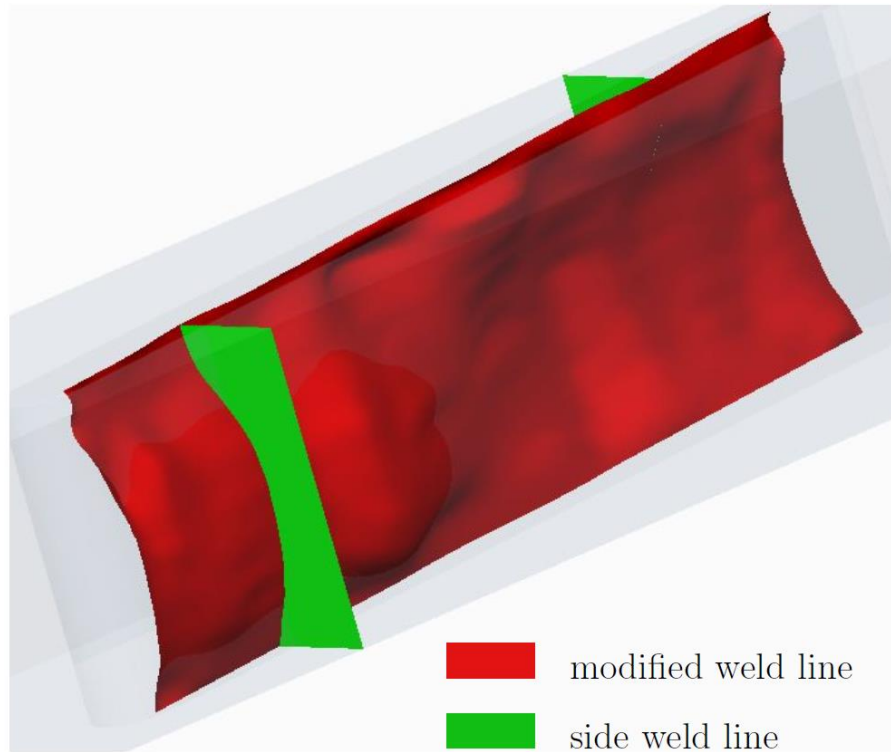


Polishes of the Modified Weldline Area

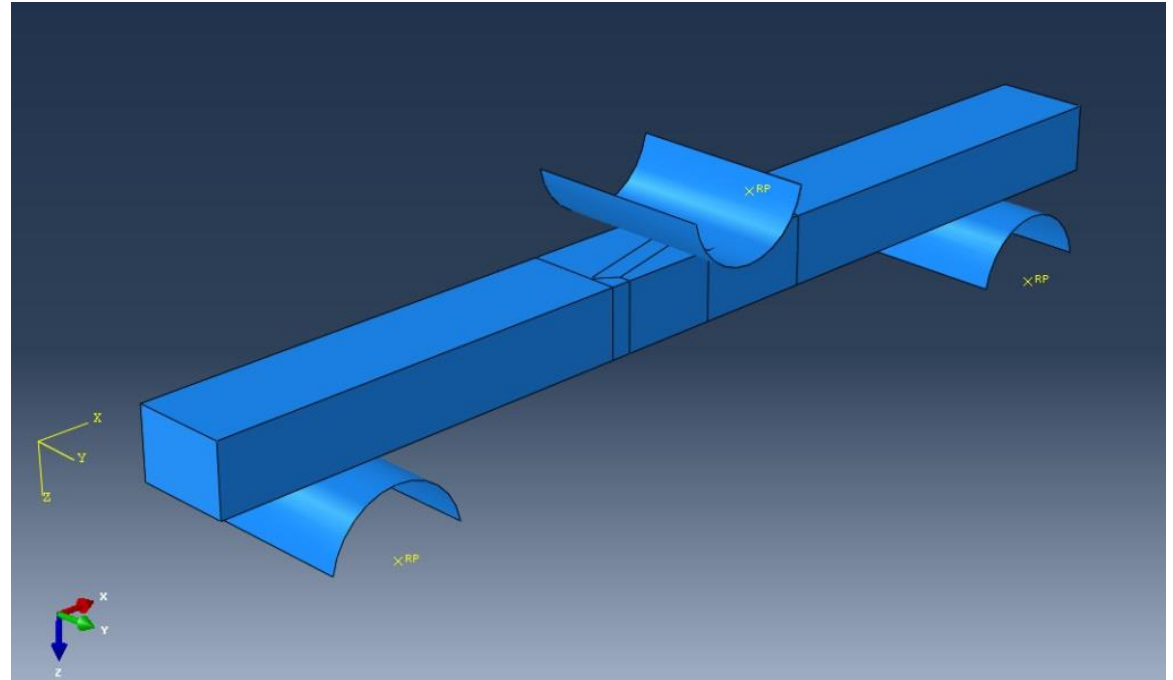
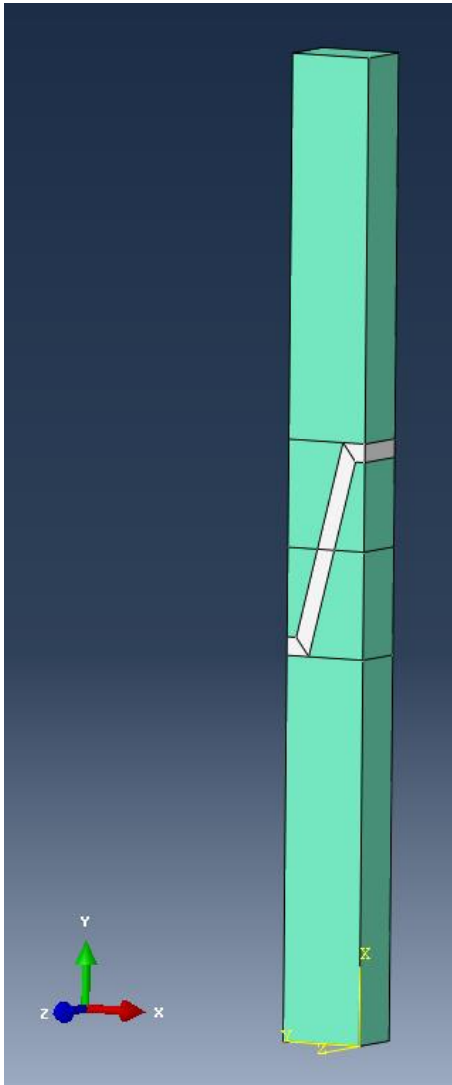
A₃ (3.17 mm from the middle)



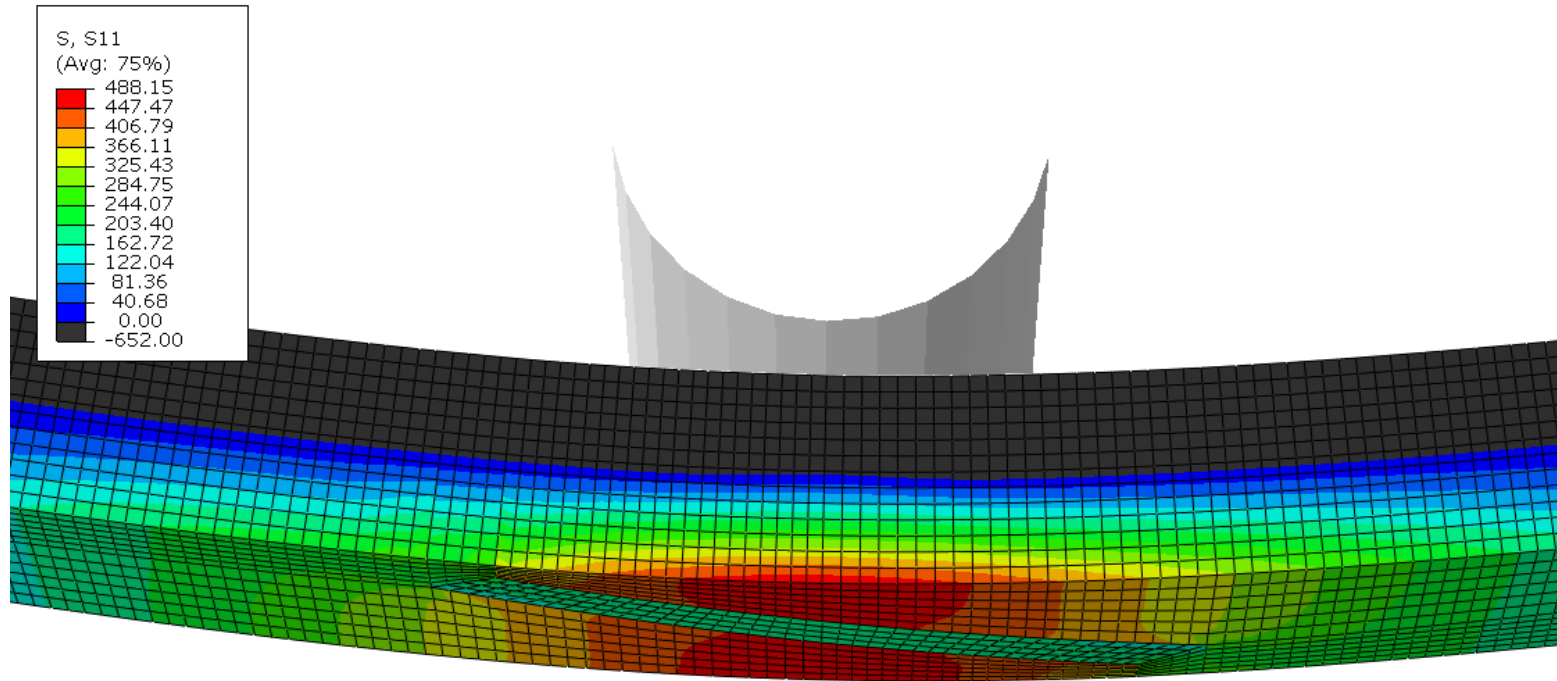
Reconstructed Modified Weldline



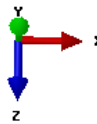
Simulation - Model



Simulation - Results

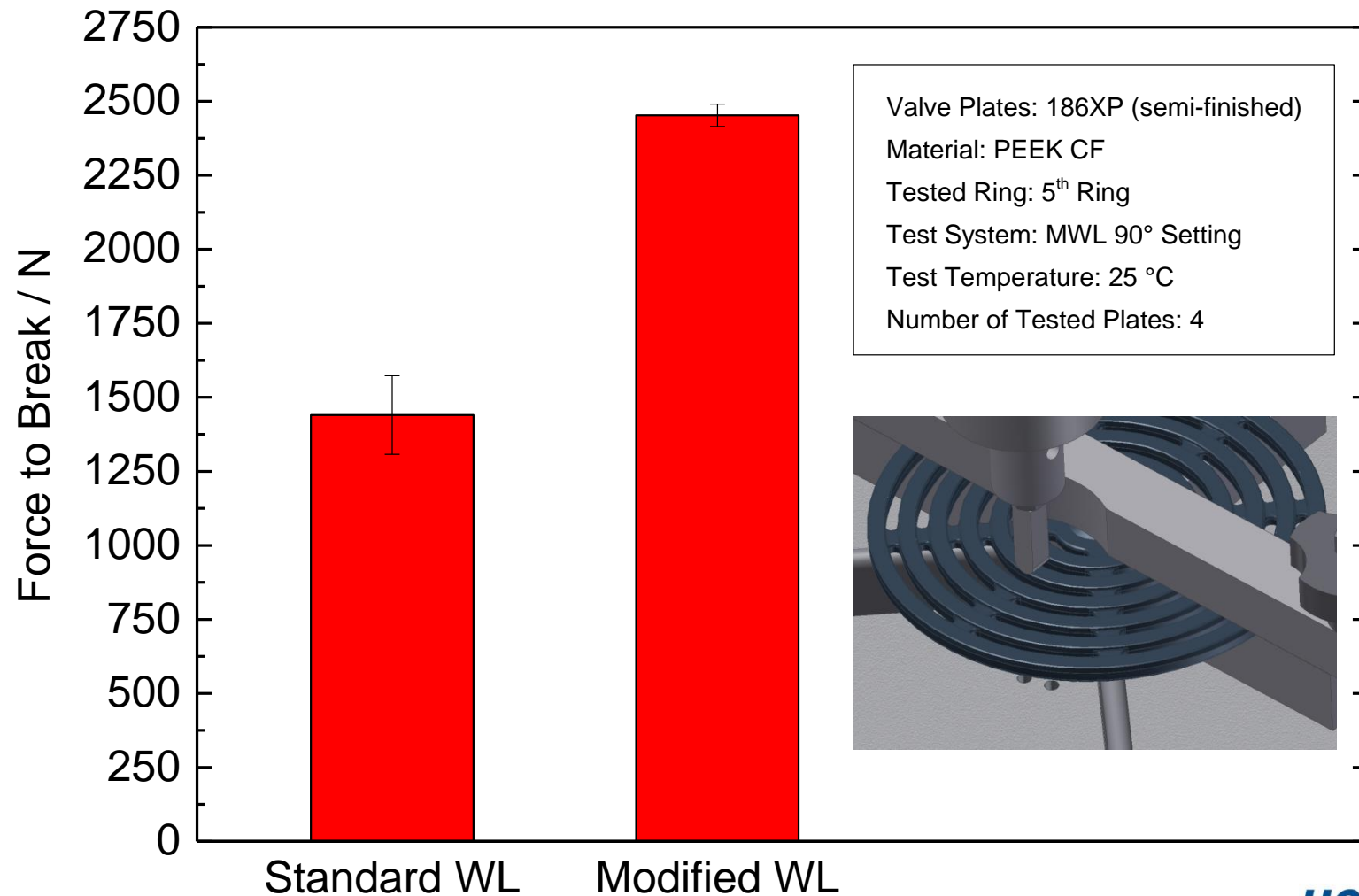


ODB: ATBending_Cor'DeLv1_Mold.odb Abaqus/Standard 6.10-1 Mon Feb 17 16:58:08 GMT+01:00 2014



Step: Displacement, Displacement
Increment: 12; Step Time = 0.6000
Primary Var: S, S11
Deformed Var: U Deformation Scale Factor: +1.00e+00

New Technology - Implementation



Next Generation Valves

~100,000 Large compressors operating worldwide

~1 MW each → 100,000 MW Energy consumption

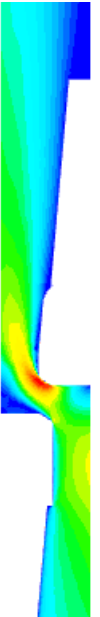
Next Generation Valves are 5% more efficient

Total savings of ~ 5,000 MW

Equivalent with

~ 10,000,000 households^[4] (0.5 kW)

~ 10,000 wind turbines



[4] Statistik Austria 2012 - Average Energy consumption per year: 4200 kWh

Thank you for your attention!

