SIMULATION OF THERMO-MECHANICAL STRAIN IN EXTRUDED POLYMER ABSORBERS FOR SOLAR THERMAL COLLECTORS

Fraunhofer-Institute for Solar Energy Systems ISE

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COMSOL CONFERENCE 2016 MUNICH

12. – 14. October 2016

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AGENDA

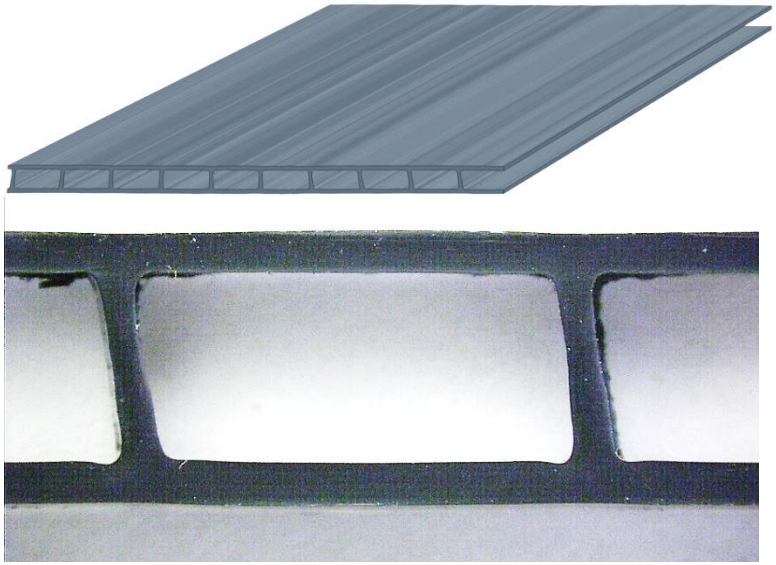
- Introduction
- Motivation and approach of investigation
- FEM Simulation
- Results
- Summary

Motivation

Application of extruded polymeric absorbers in solar heating collectors

Solar heating as ecological alternative to fossil energies is still rare due to high costs of the systems

- Extrusion polymeric absorbers
  - Cost saving
  - Variable length
- Deformations of cross section geometry
  - Contraction while cooling-down

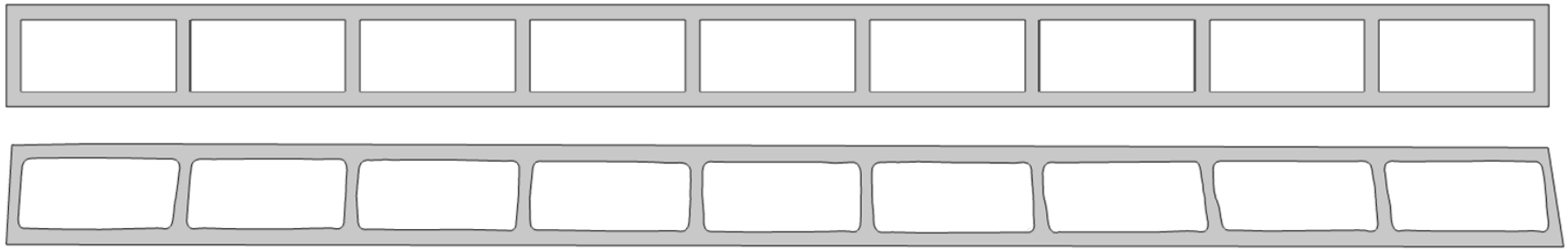


Might cause allocation of the thermo-mechanical stress in the absorber and reduce the service life of the material

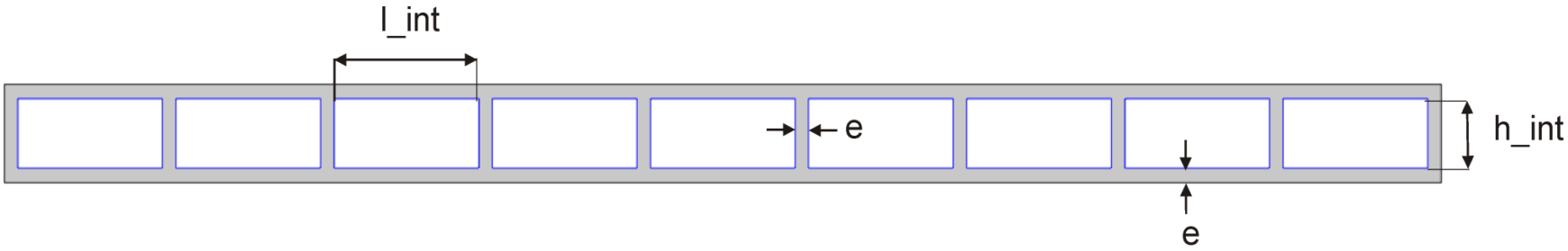
Approach of investigation

Influence of the extrusion imperfections on the distribution of thermal tension in the polymer

- To date, there are only studies of ideal / simplified structures
- Composing of real structures in comparison to the ideal geometry



- Ideal geometry: orthogonal and perfect edges



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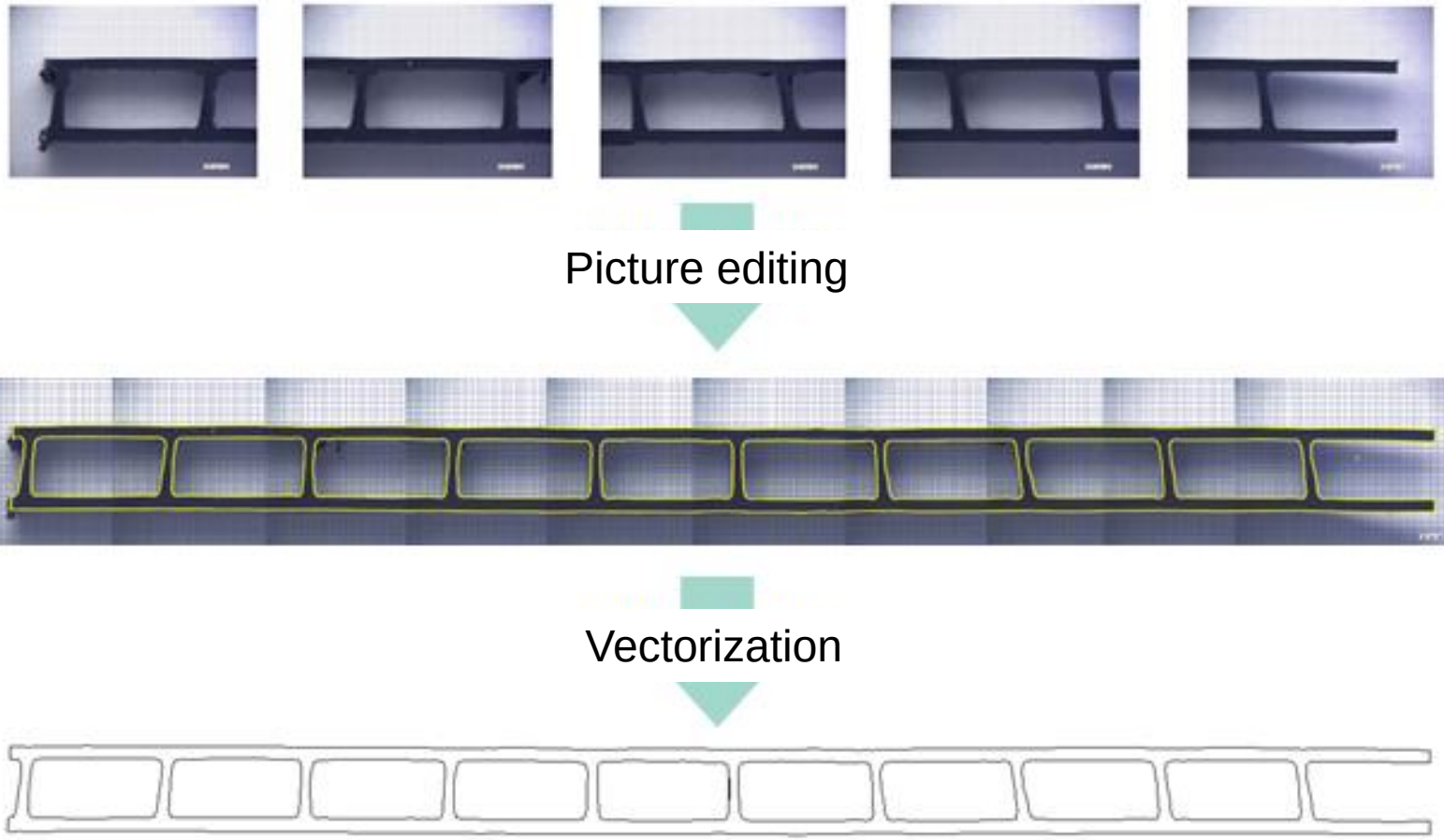
FEM Simulation

Geometry of the real absorber

- Photomontage of Microscopy pictures



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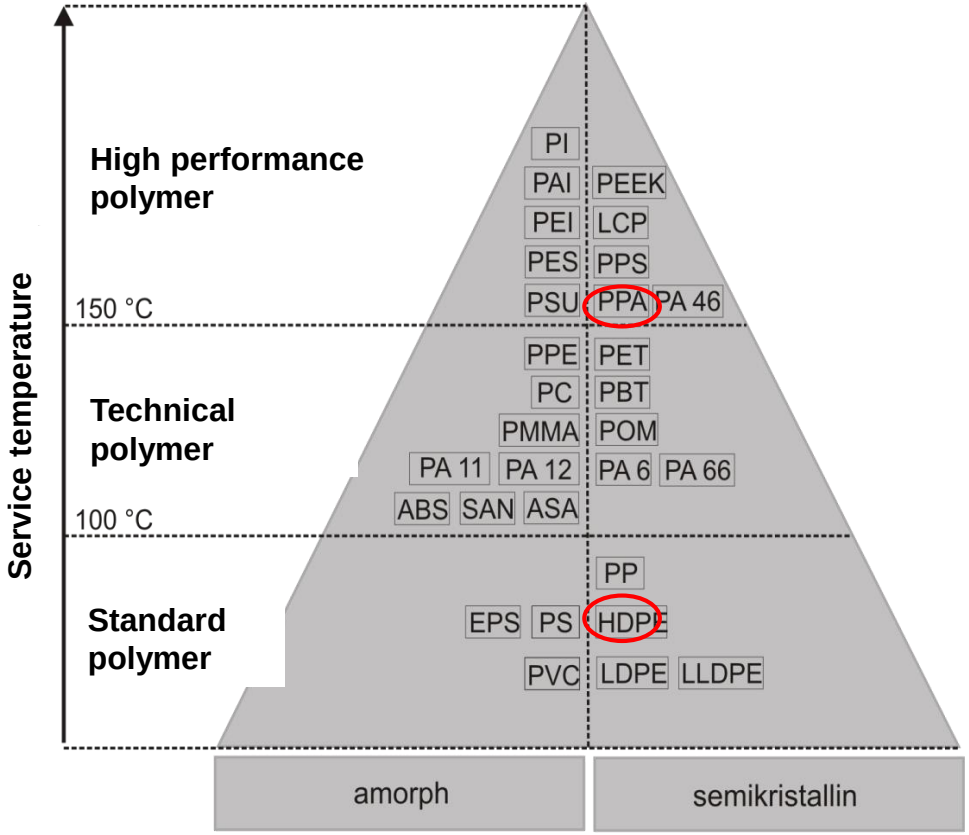
FEM Simulation
Materials

- Polypropylene (PP)
- Polyphenylene sulfide (PPS)
- Differences:
  - Thermal stability
  - Production temperature
  - Mechanical characteristics
  - Production defects



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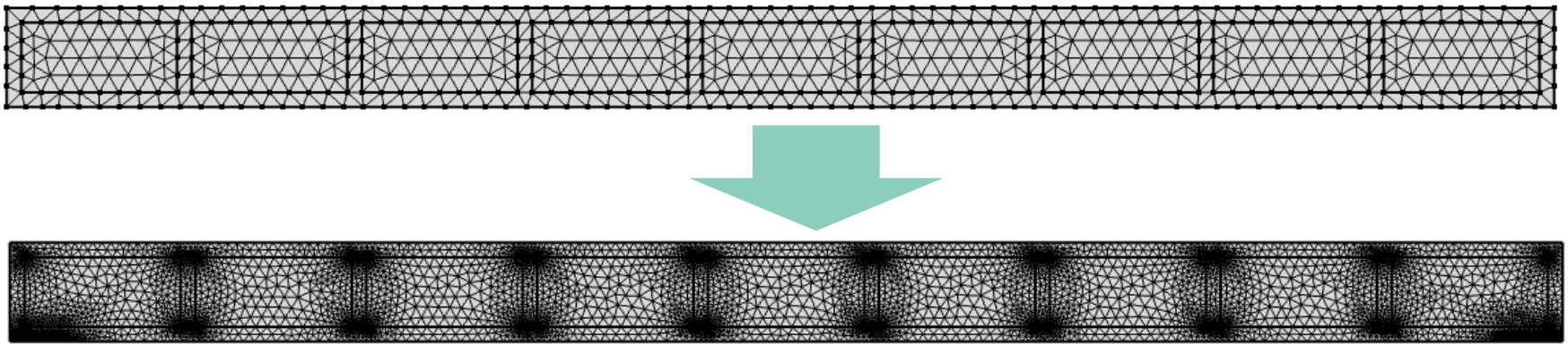
FEM Simulation
Mashing

- According to the expected tensions within structure
- Refinement
  - Corners: abrupt change of structure geometry
  - Surfaces: physical conditions

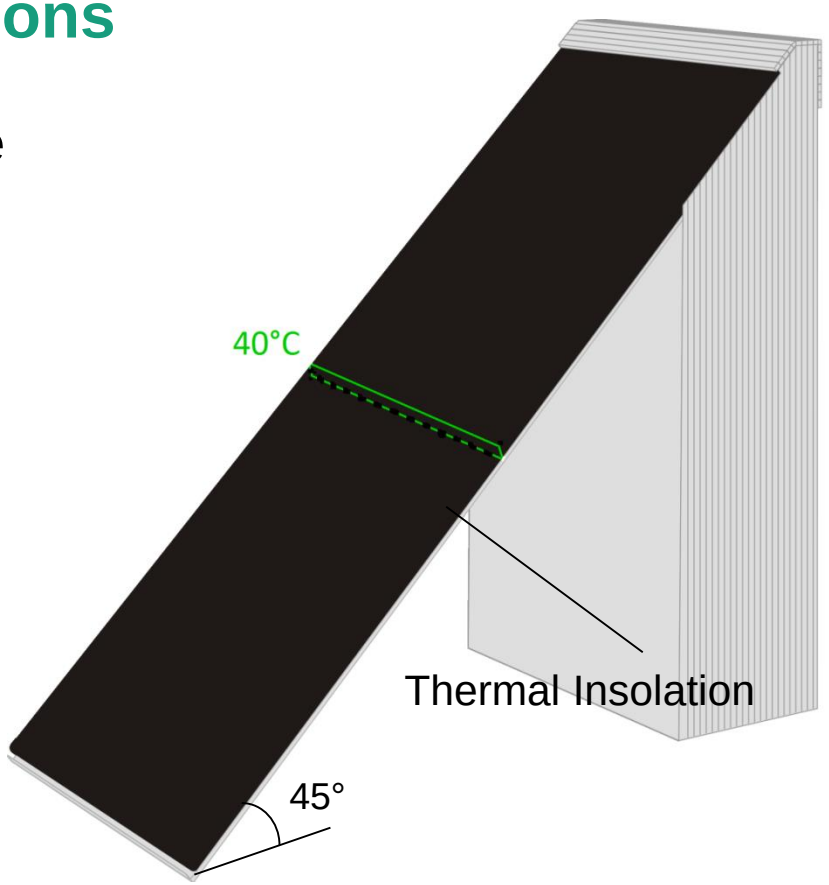
Double bars



FEM Simulation

Definition of boundary conditions

- Simulation of a cross section of the absorber
- Angle of slope 45°:
  - Gravity (no pump ect.)
  - Const. convective heat transfer through fluid flow of v = 1 m/s
- Isolation block
  - Thermal isolation on the backside



Thermosiphon System ThermX, Project

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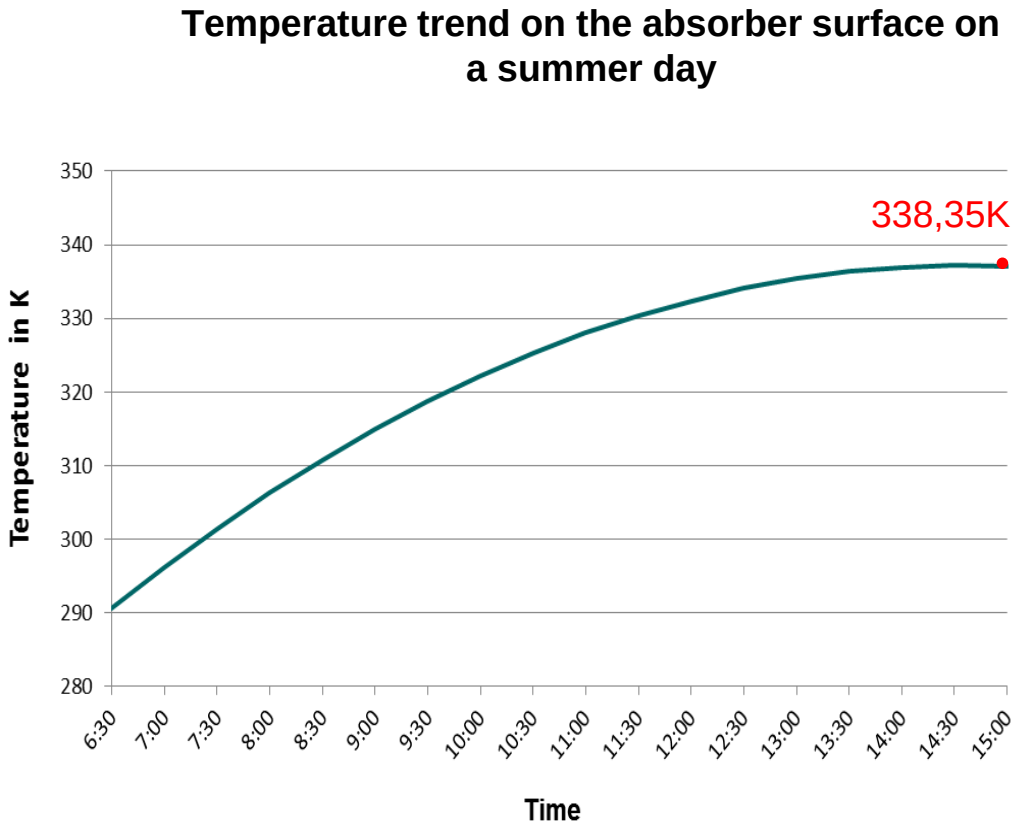
FEM Simulation
Thermal conditions

Further parameter conditions for time-dependent calculation of tension and deformation

- Measured surface temperature T_A = 65°C (mid absorber)
- Water in the cross section of the absorber T_{H2O} = 40°C

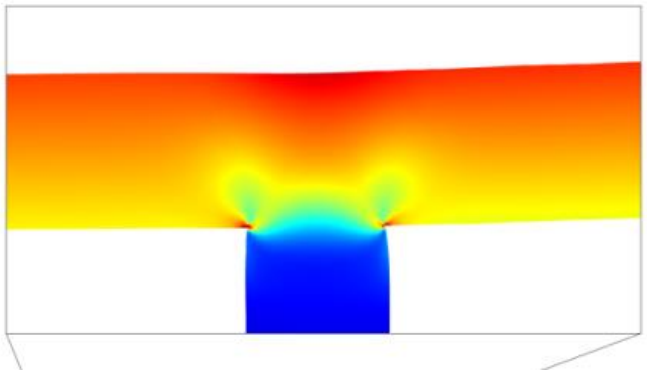


FEM Simulation

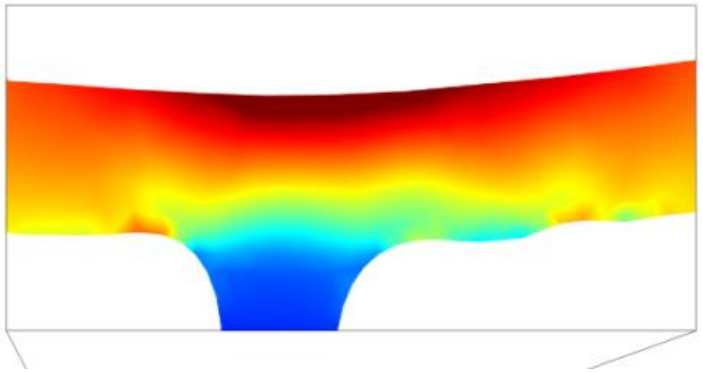
Results of deformation calculation (PPS absorber)

- Allocation of the tension and exaggerated diagram of the attended deformation for T_A = 338,35K

Ideal structure



real structure



Local exaggeration of tension:

Edges

concave defect

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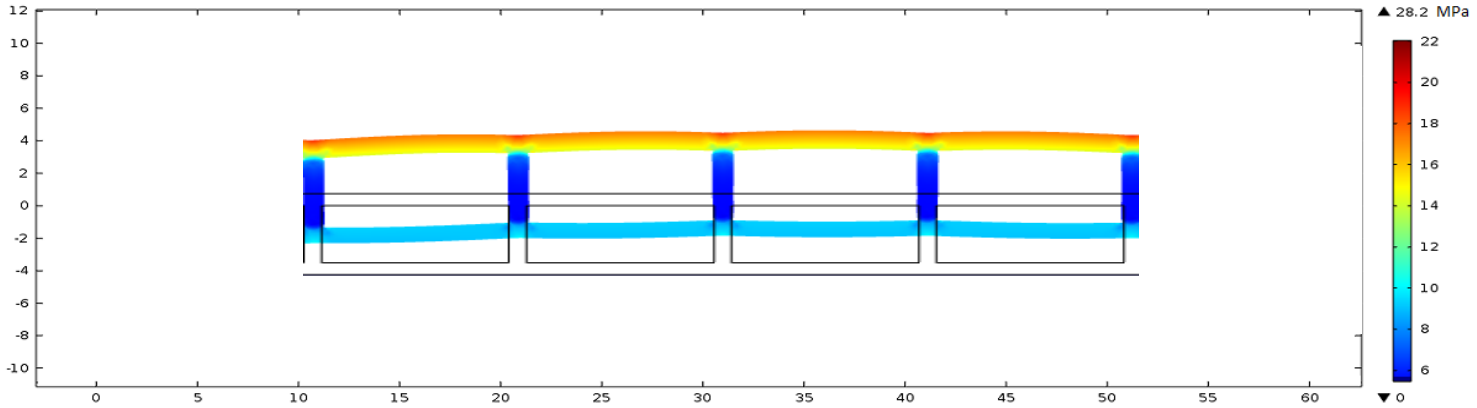
FEM Simulation

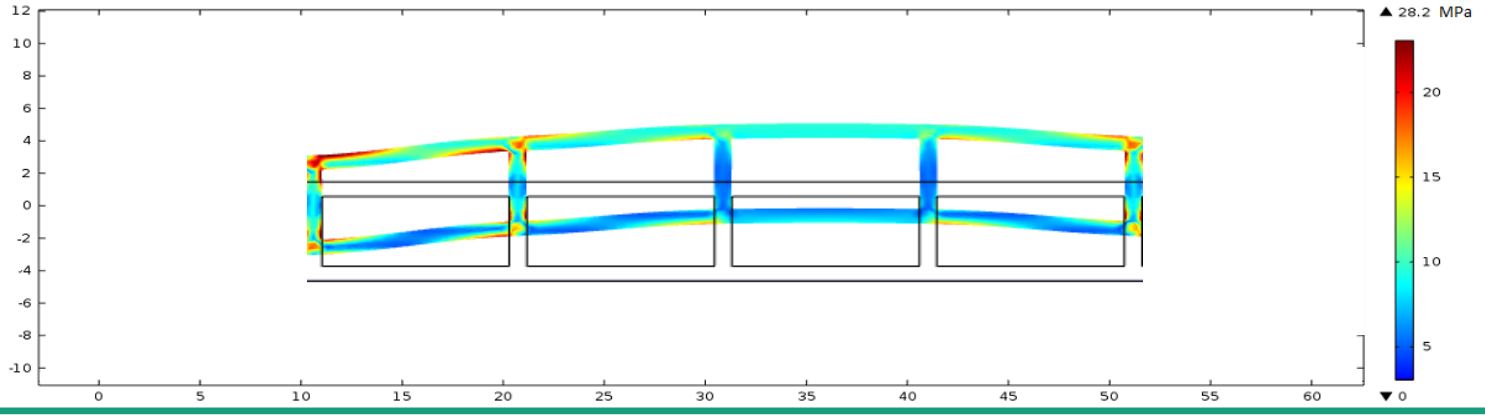
Results of material comparison (PPS vs. PP)

- Comparison of the tension in the absorber
- Exaggerated diagram of the deformation for T_A = 338,35K

PPS



PP



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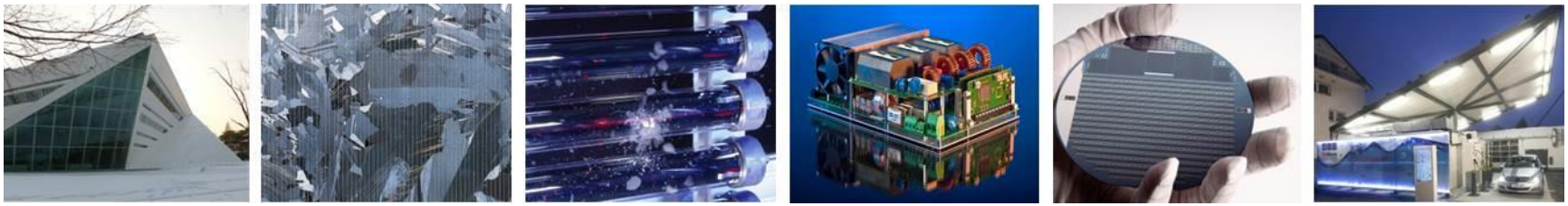
Summary and further work
Extruded polymer absorbers in solar heating systems

- Demonstration how a real geometry can be translated with ordinary instruments in a digital model
- Simulation of ideal geometry indicate insufficient or even false results
- Investigation of the real extrusion deformation and the local tension exaggeration
  - Major increase of tension at the edges of the ideal compared to the edges of the real structure; The sharper the edges, the larger the tension
  - Higher tension values using PPS than using PP (PP: lower thermal expansion coefficient)
  - Less deformation in PPS than in PP (PP: lower E-module)
- Optimization of production processes and material service life through identification of the weak spots in the deformable components

Thank you for the attention



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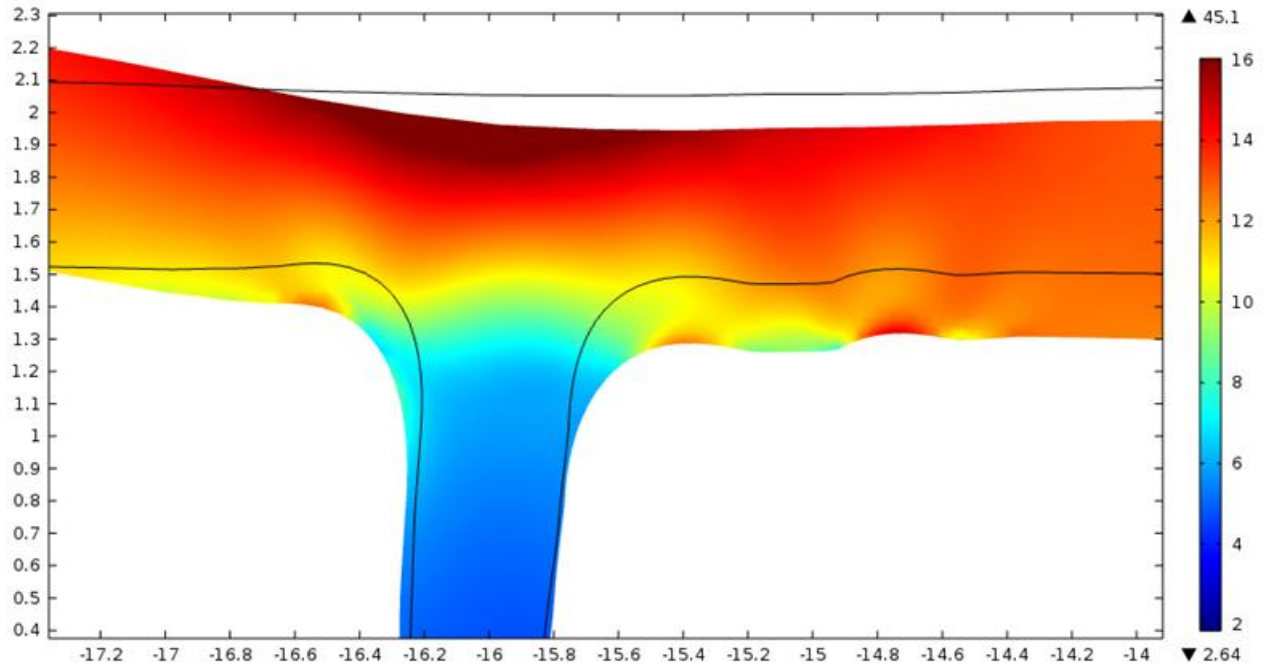
FEM Simulation

Results real structure



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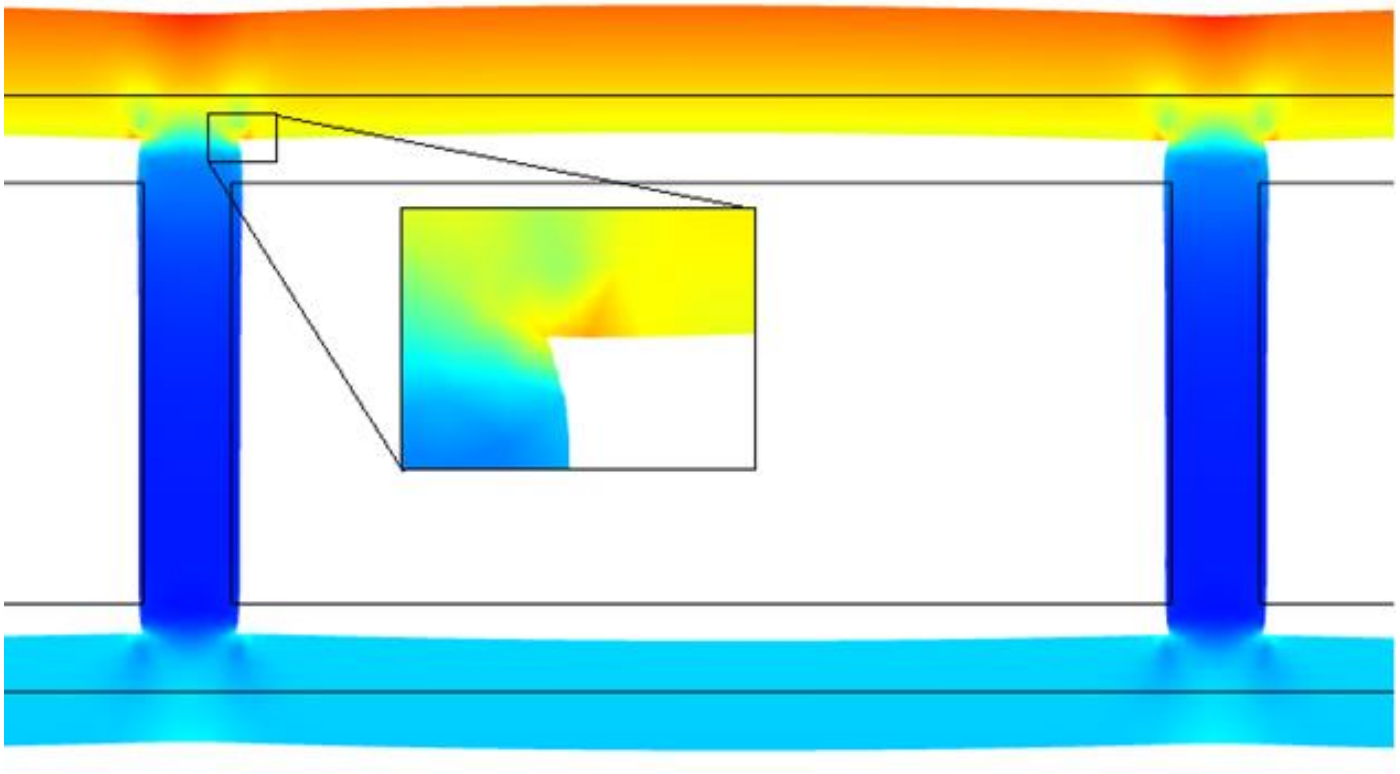
FEM Simulation
Results ideal structure

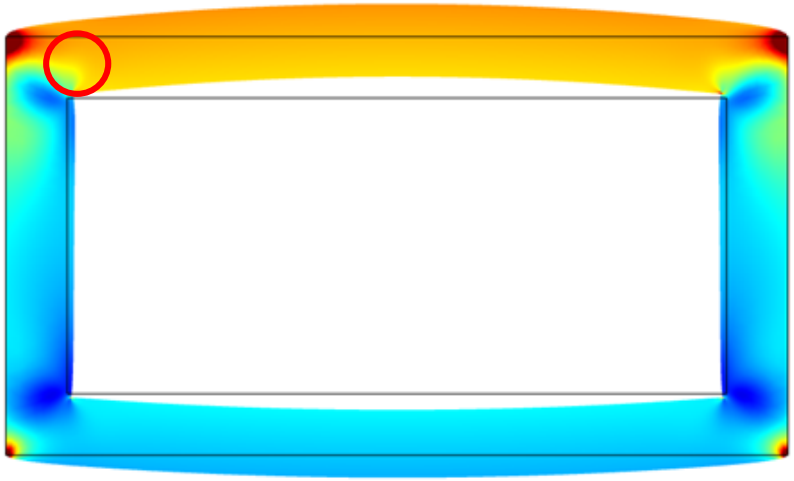
- Local tension increasing above the edges of the ducts



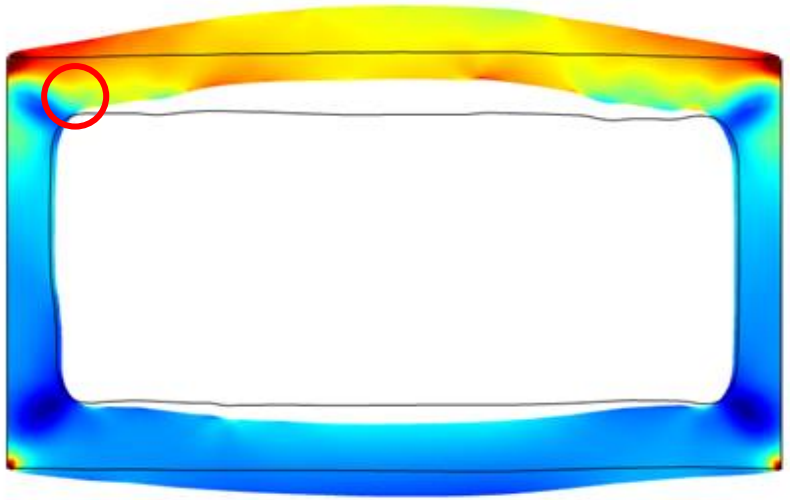
FEM Simulation

Results tension comparison

Ideal structure



Real structure



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