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

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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
FEM Simulation
Geometry of the real absorber

- Photomontage of Microscopy pictures

Picture editing

Vectorization
FEM Simulation
Materials

- Polypropylene (PP)
- Polyphenylene sulfide (PPS)

**Differences:**
- Thermal stability
- Production temperature
- Mechanical characteristics
- Production defects
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 etc.)
  - Const. convective heat transfer through fluid flow of $v = 1 \text{ m/s}$

- Isolation block
  - Thermal isolation on the backside

Thermosiphon System ThermX, Project

Thermal Insolation
FEM Simulation

Thermal conditions

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

- Measured surface temperature $T_A = 65^\circ$C (mid absorber)

- Water in the cross section of the absorber $T_{H2O} = 40^\circ$C

Temperature trend on the absorber surface on a summer day
FEM Simulation
Results of deformation calculation (PPS absorber)

- Allocation of the tension and exaggerated diagram of the attended deformation for $T_A = 338.35K$

Local exaggeration of tension:
- Edges
- Concave defect
FEM Simulation

Results of material comparison (PPS vs. PP)

- Comparison of the tension in the absorber
- Exaggerated diagram of the deformation for $T_A = 338.35K$
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
FEM Simulation

Results ideal structure

- Local tension increasing above the edges of the ducts
FEM Simulation

Results tension comparison

Ideal structure

Real structure