Motion and Strength Simulations

Aalto University
School of Engineering

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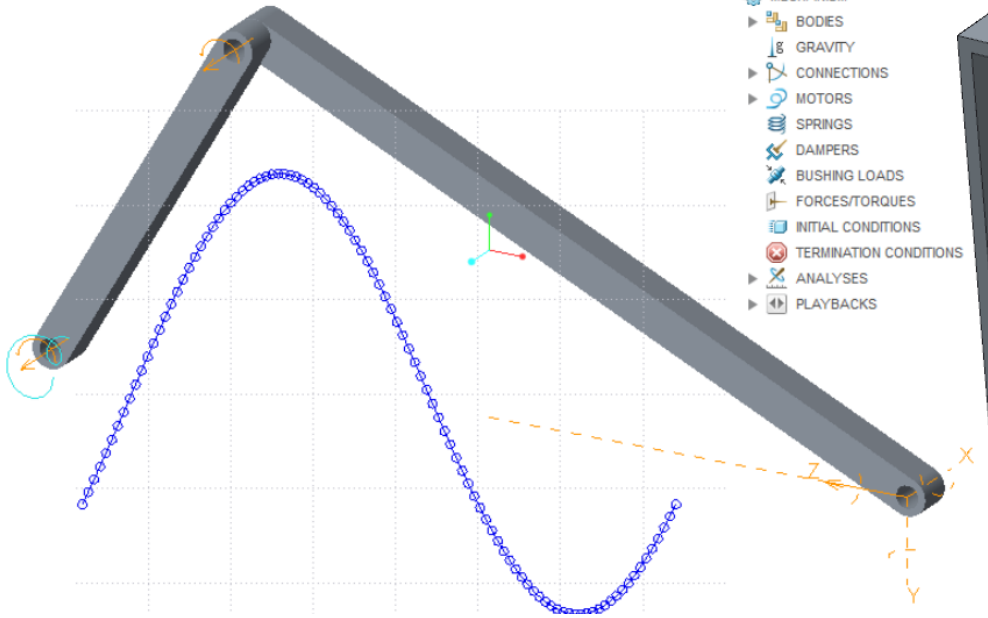
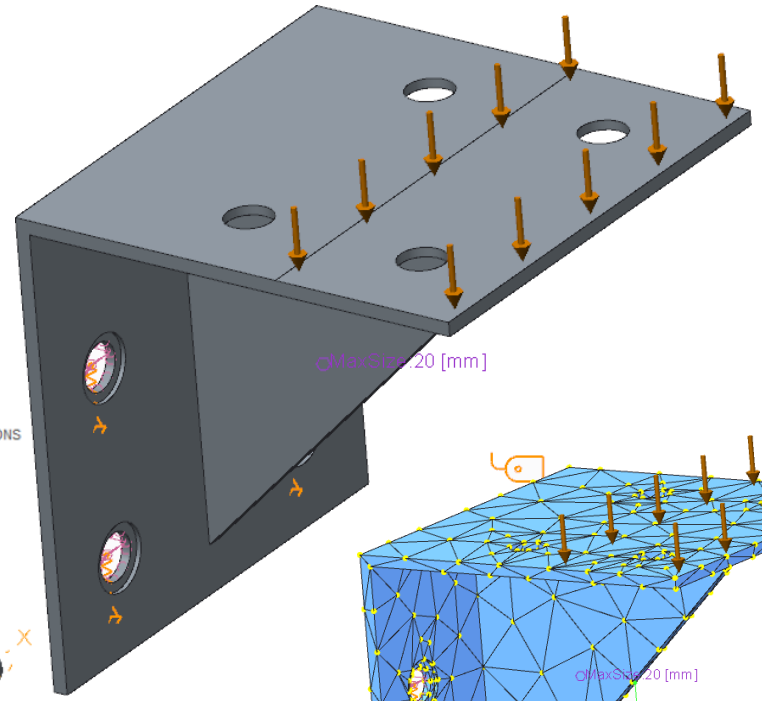
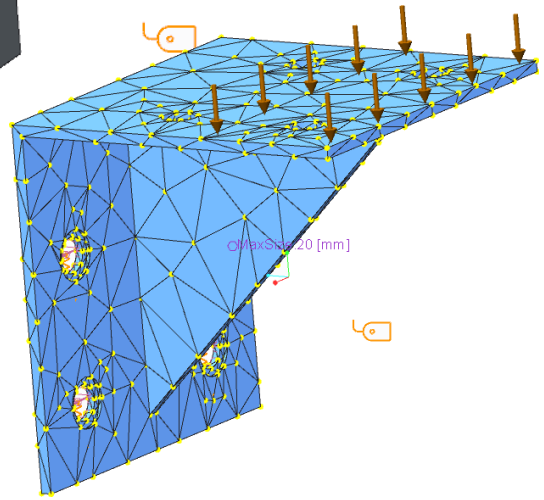
This Week's Tasks







Motion Simulations

MBS

Multi-body Simulation

Studies behavioral of mechanism

- Motion and velocities (kinematics)
- Forces and torques (dynamics)
- Contacts

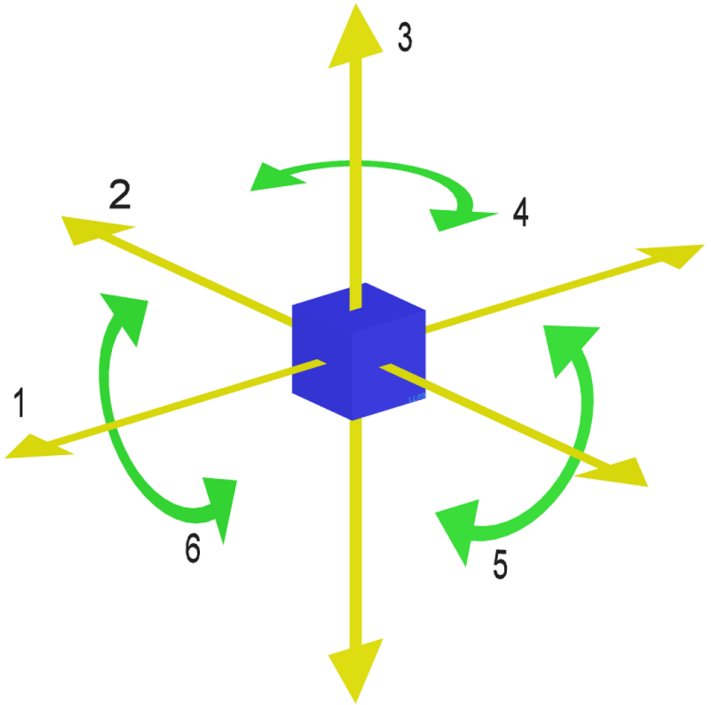
Can be as integrated module in CAD or separate software

Degrees of Freedoms

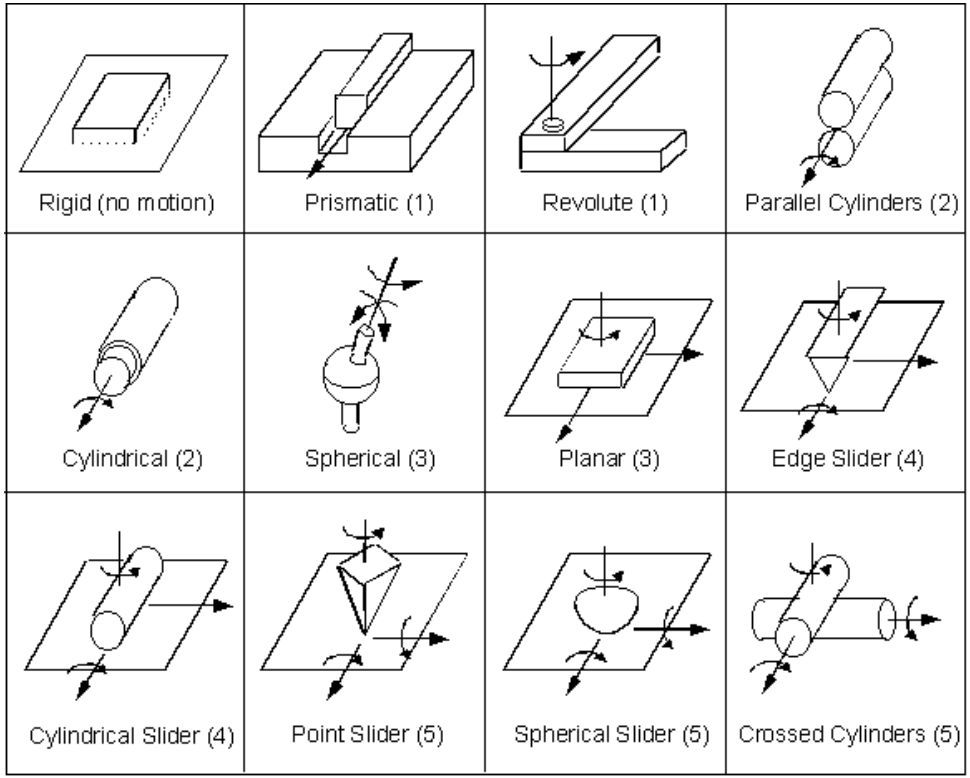
DoFs

Object in 3D world

- 3 translations
- 3 rotations



Joints

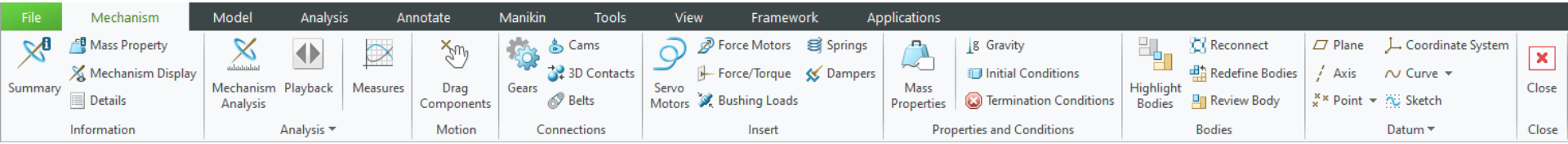

Rigid (no motion)
Prismatic (1)
Revolute (1)
Parallel Cylinders (2)
Cylindrical (2)
Spherical (3)
Planar (3)
Edge Slider (4)
Cylindrical Slider (4)
Point Slider (5)
Spherical Slider (5)
Crossed Cylinders (5)

Creo Mechanism

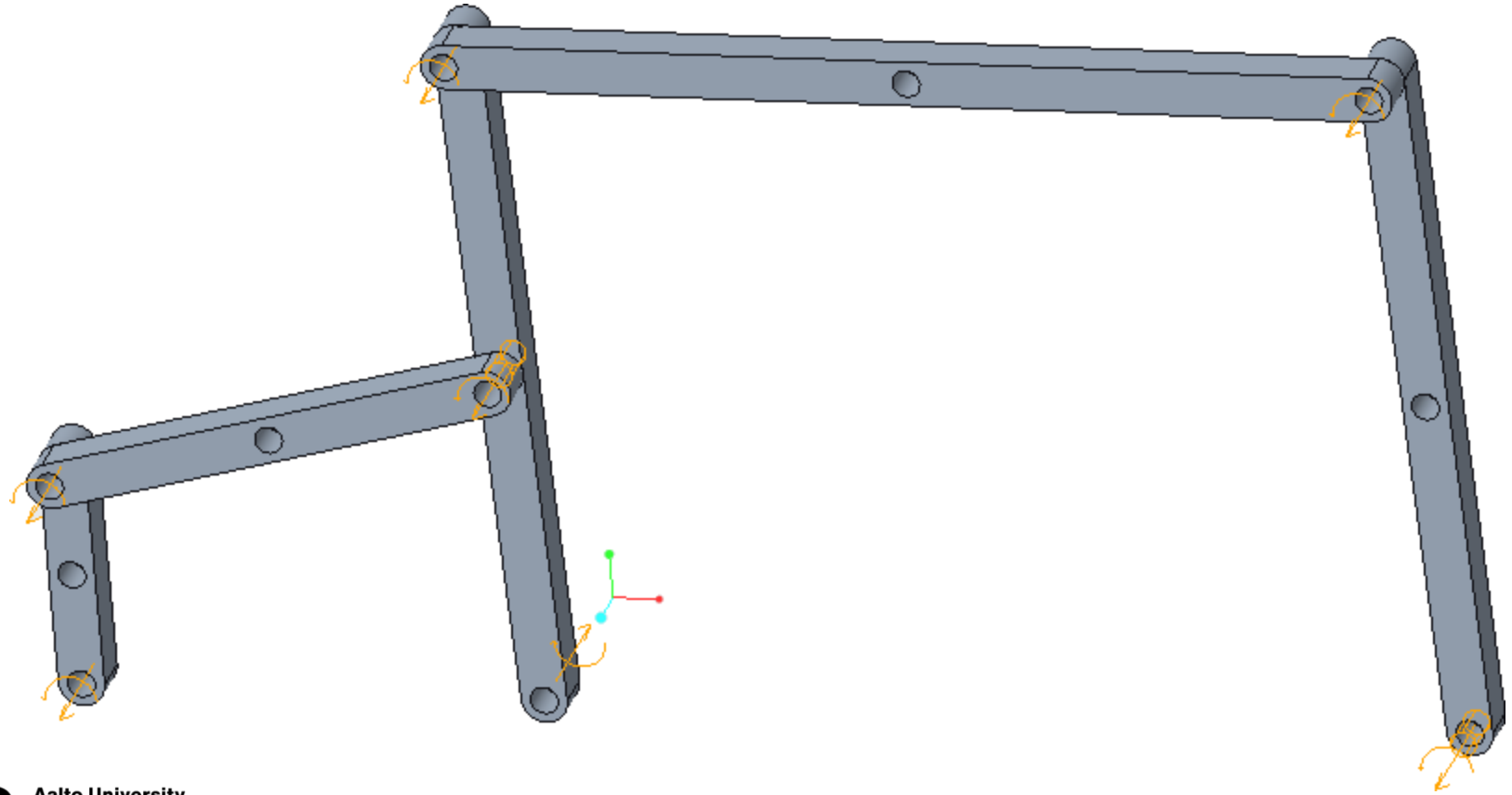
Integrated MBS application

Can affect behavioral of assemblies

- For ex. Gears in Clock Assembly



Demo



Other MBS software

Stand-alone

- MSC Adams
- SIMPACK

Integrated in CAD

- NX Motion
- Solid Works Motion Simulation
- Etc.

Strength Analyses

Creo Simulate 

Creo’s FEM module

- Strength
- Vibration
- Fatigue
- Thermal
- Optimization

Workflow

Material

- Assign material to simulation model 

Constrains

- How model is attached to ground, what can move etc. 

Forces

- What loads model have, is there gravity etc. 

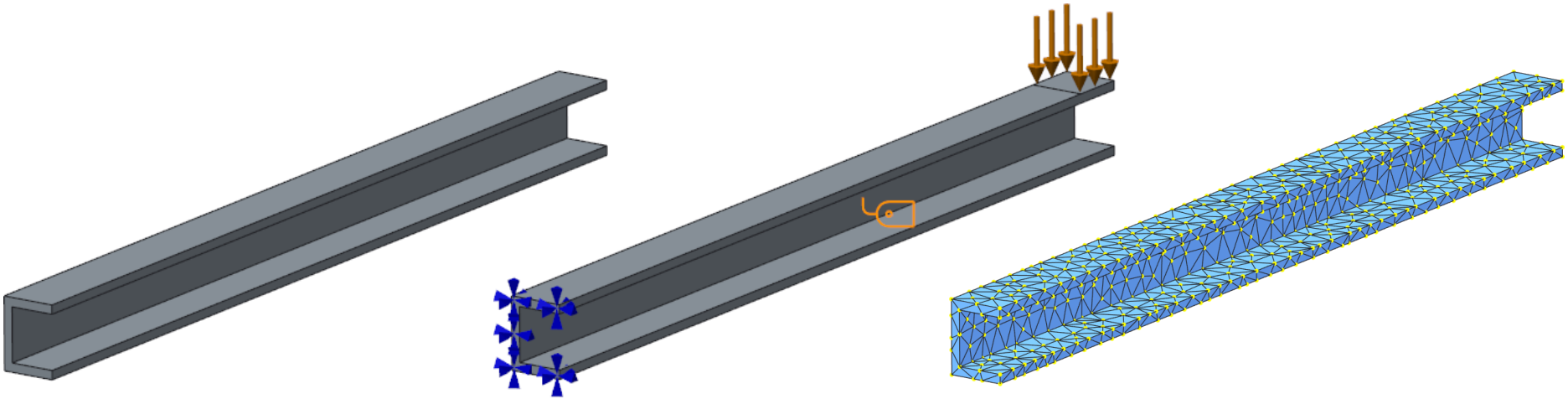
Run simulation

- Meshing, what and how is calculated 

Checking results

- What happened and where? 

Example Simulation Process



Geometry

Constrains

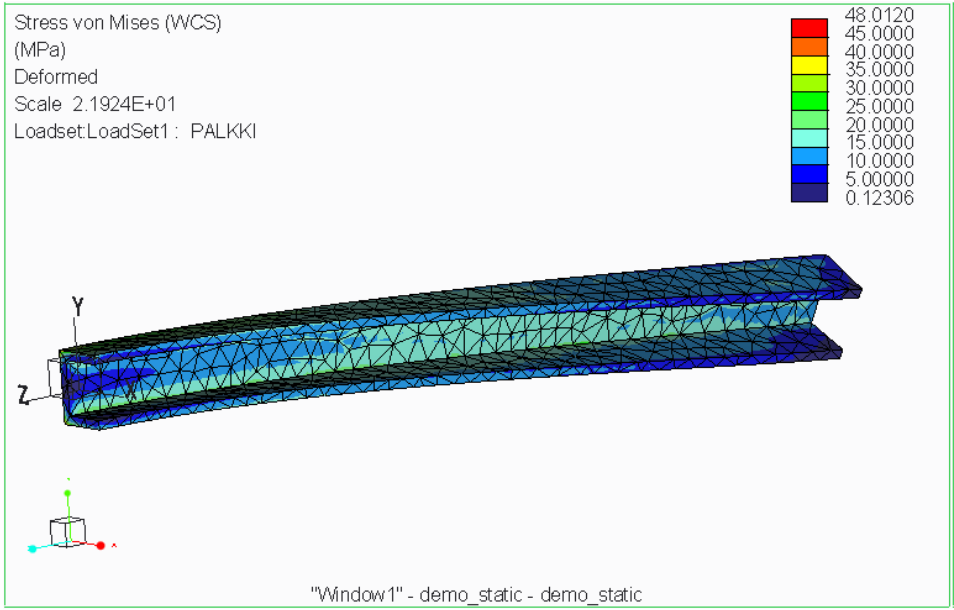
Attachment, forces, material

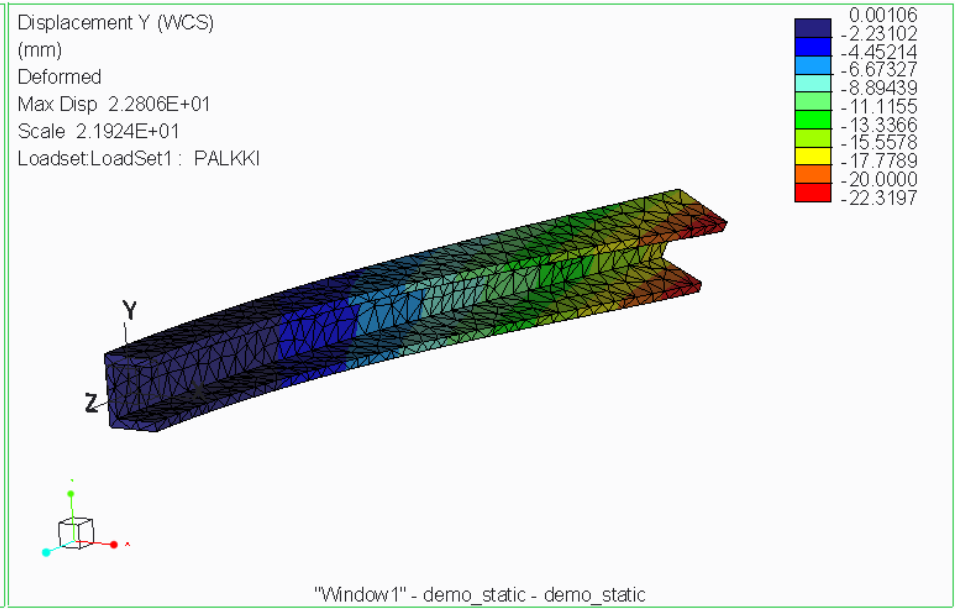
Meshing

Shape, size etc.

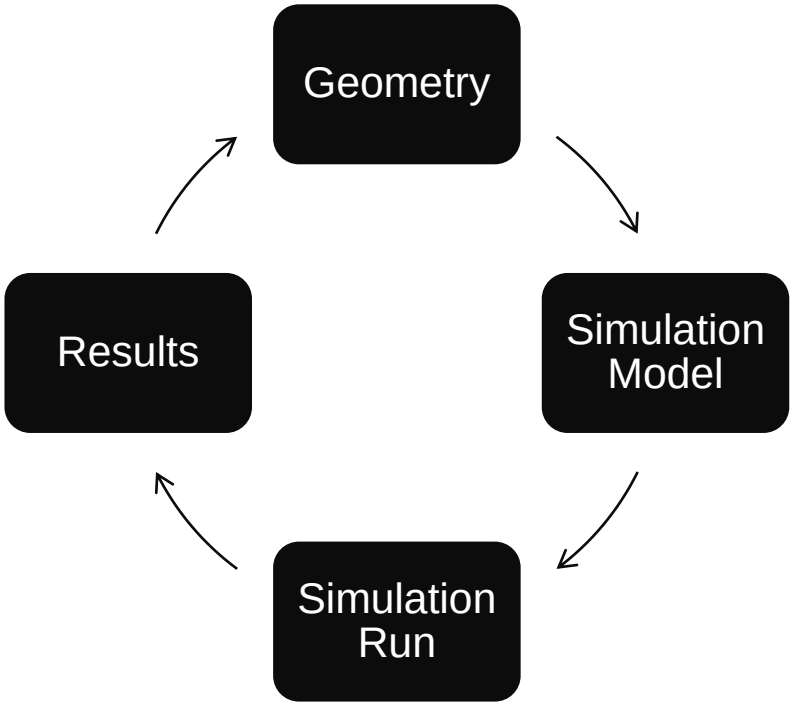
Example Simulation Process

Analyzing the results





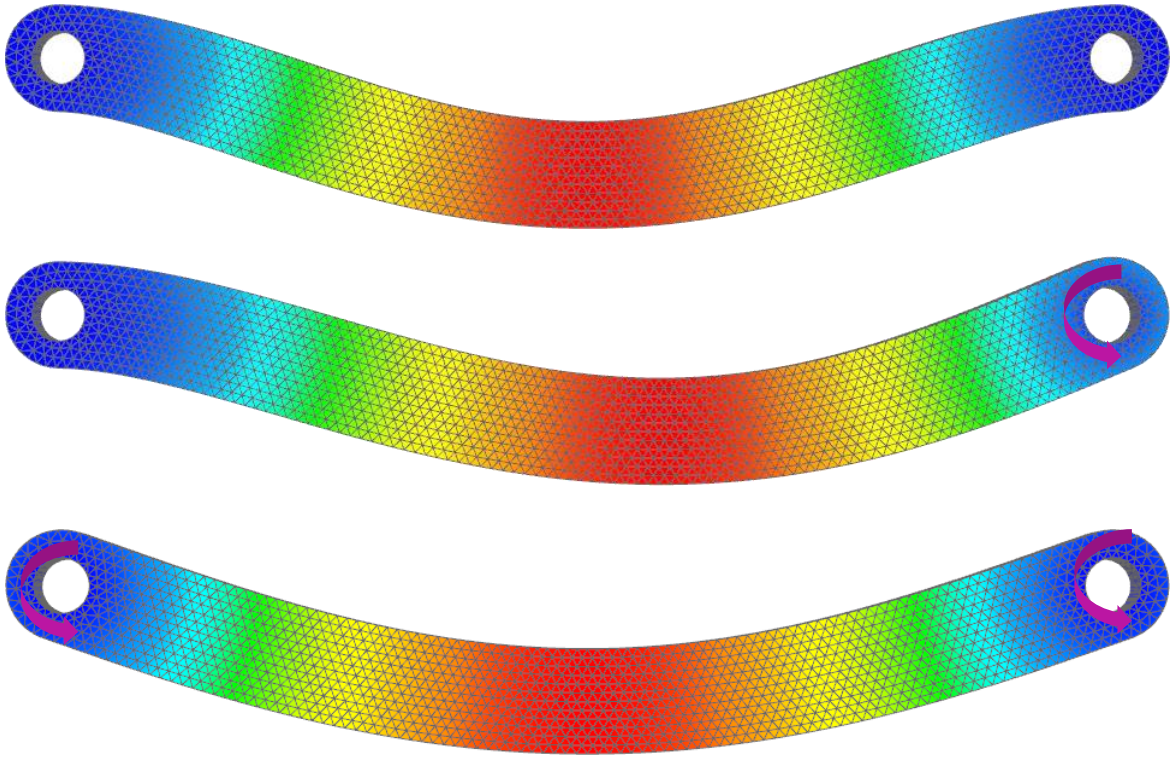
Iterative Process



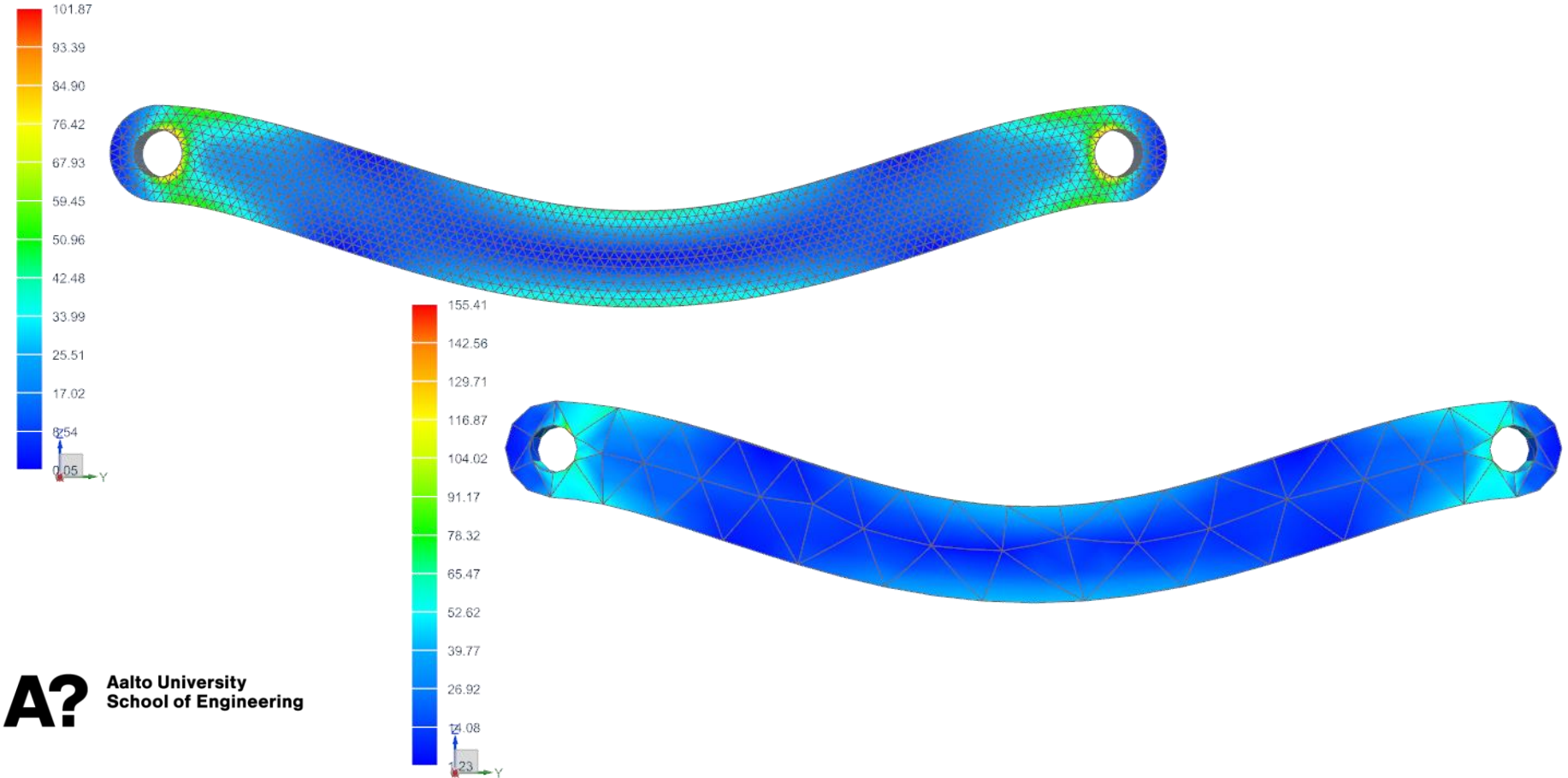
Constrains

Constrain type affects results

- Fixed vs
- Revolute



Mesh Element Size



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Mesh Element Size

Element

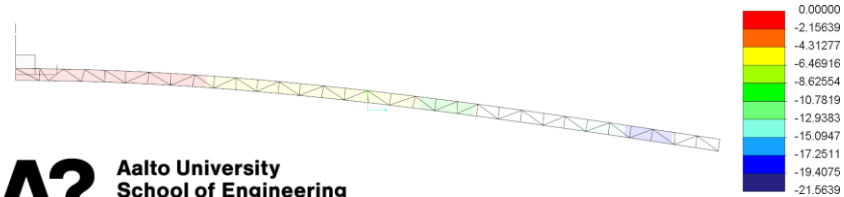
- Max size 250 mm
- 292 pcs

Calulation time

- 0:00:01

Created files

- 3,31 MB



Element

- Max size 10 mm
- 536888 pcs

Calulation time

- 0:58:40

Created files

- 4,29 GB

Validation

All inputs and accuracy of inputs affect outcome

It is a good practice to validate your results

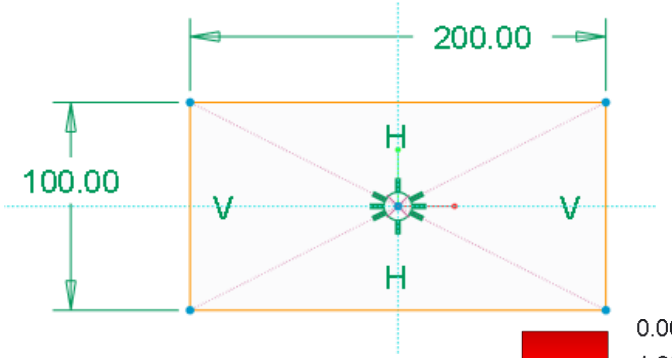
- With basic hand calculation equations $$w''(x) = -\frac{M(x)}{E \times I(x)}$$
- For example in beam case with fixed load and fixed shape
  - I and F are constant

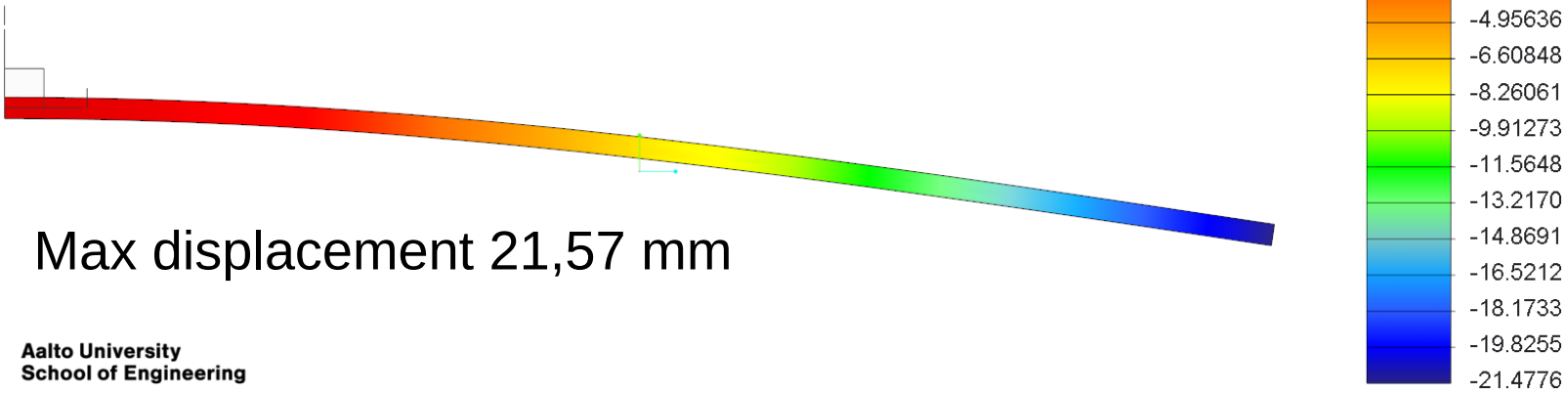
$$w_y(x) := \frac{F \cdot L^3}{6 \cdot E \cdot I_{yy}} \cdot \left(3 \cdot \frac{x^2}{L^2} - \frac{x^3}{L^3}\right)$$

Validation

Beam

- Length 6 m (100 mm elements)
- 1 kN force in the free end
- Steel as material





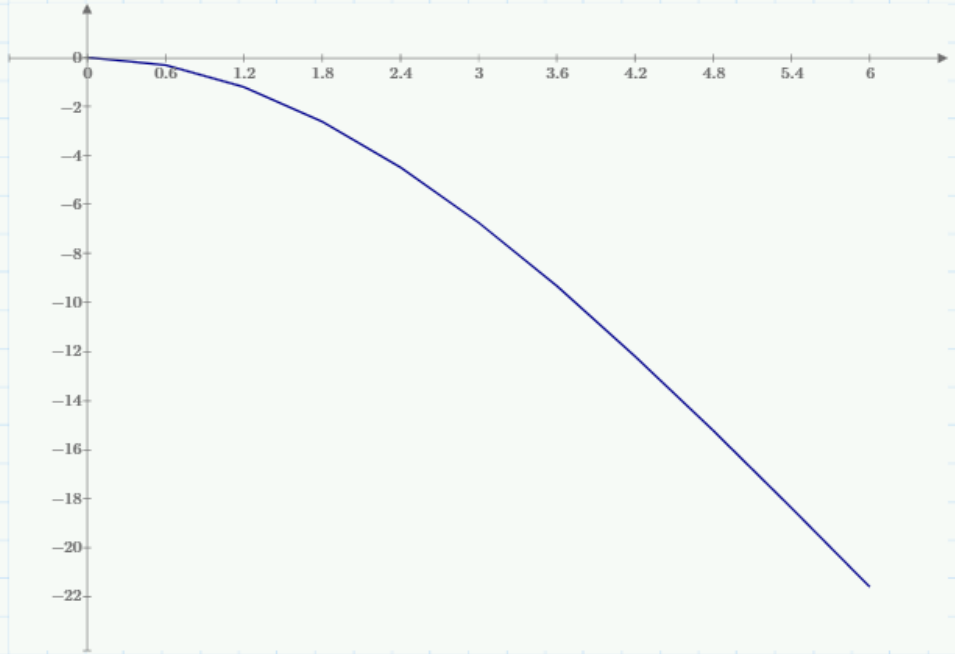
- Max displacement 21,57 mm

Validation

With Matchcad

Results

$v(L) = -21.6\ mm \qquad v(0.5 \cdot L) = -6.75\ mm \qquad x := 0, 0.1\ L .. L$

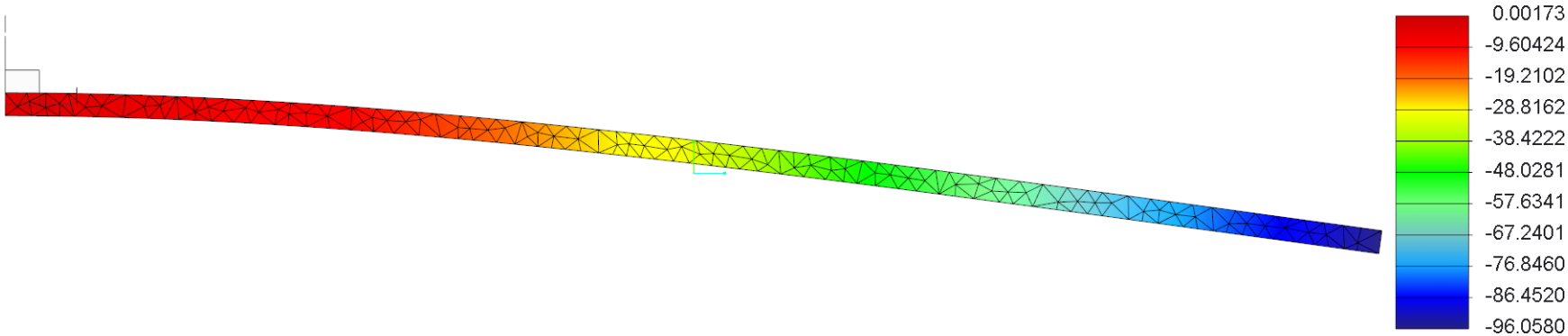


$v(x)\ (mm)$

Validation

With gravity

- Max displacement 96,06 mm

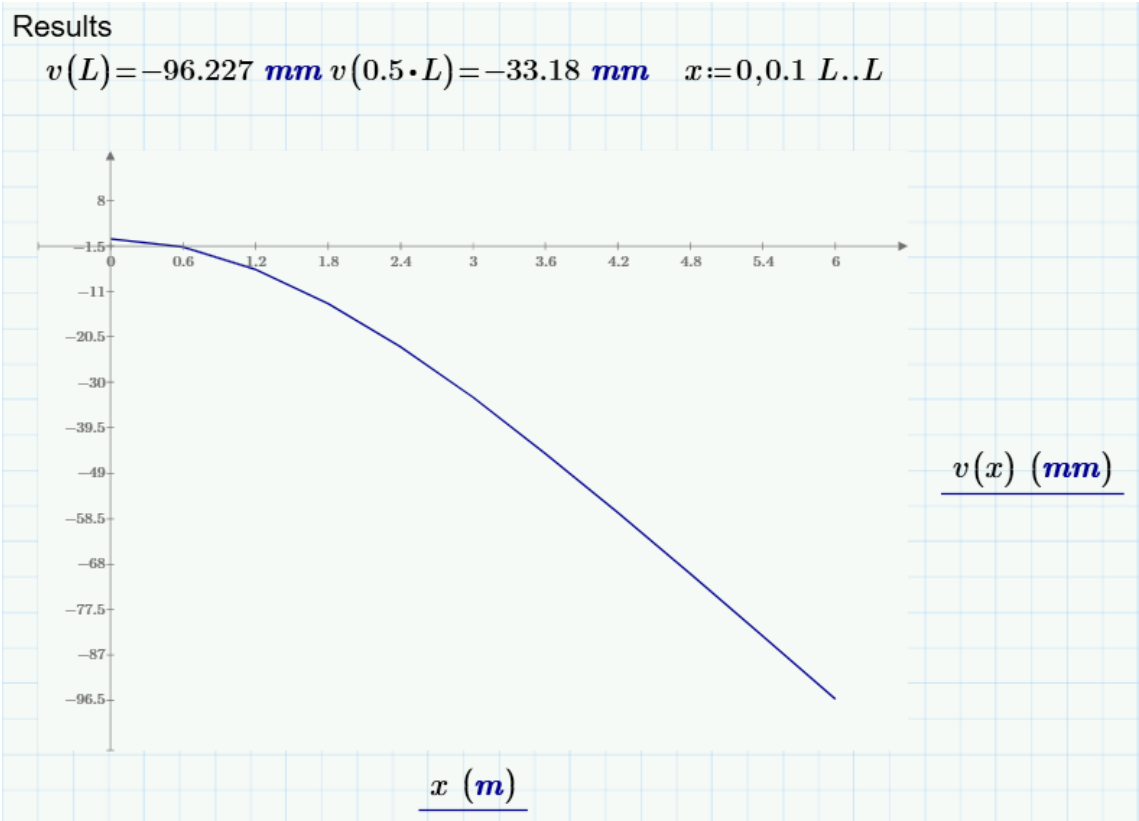


Validation

Mathcad with gravity

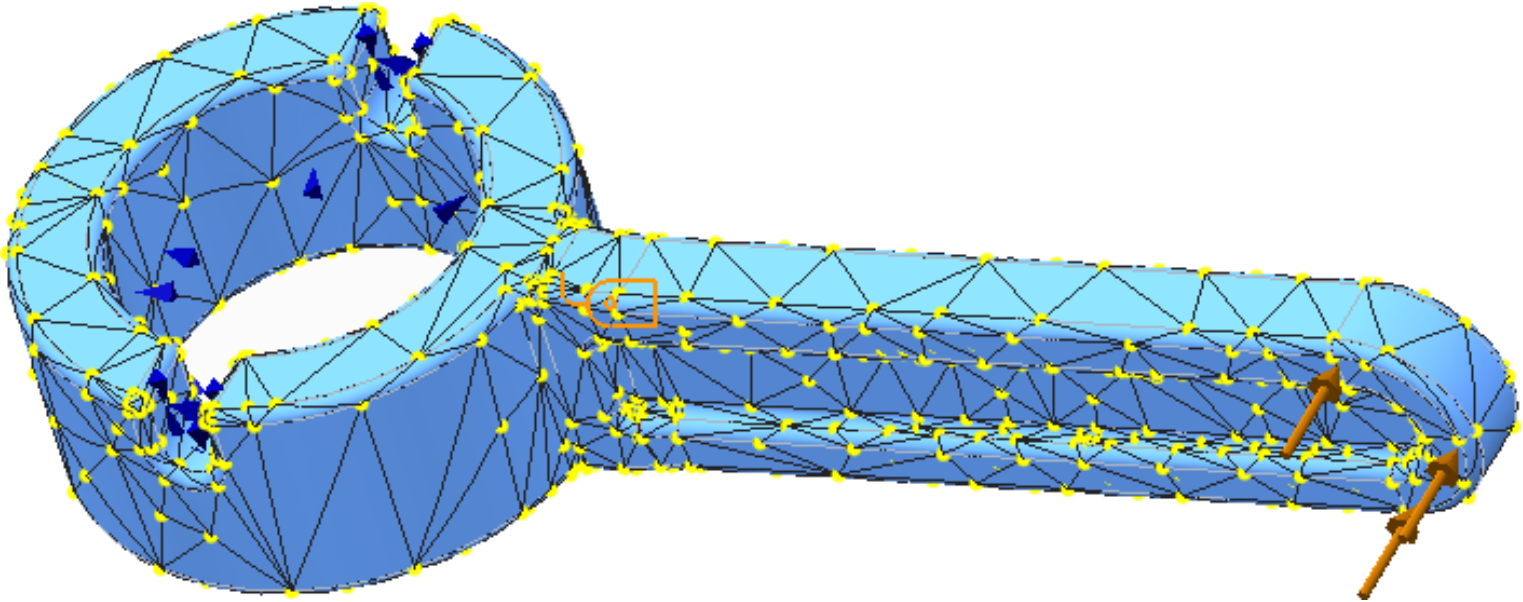
Results

$v(L) = -96.227\ mm \quad v(0.5 \cdot L) = -33.18\ mm \quad x := 0, 0.1\ L .. L$



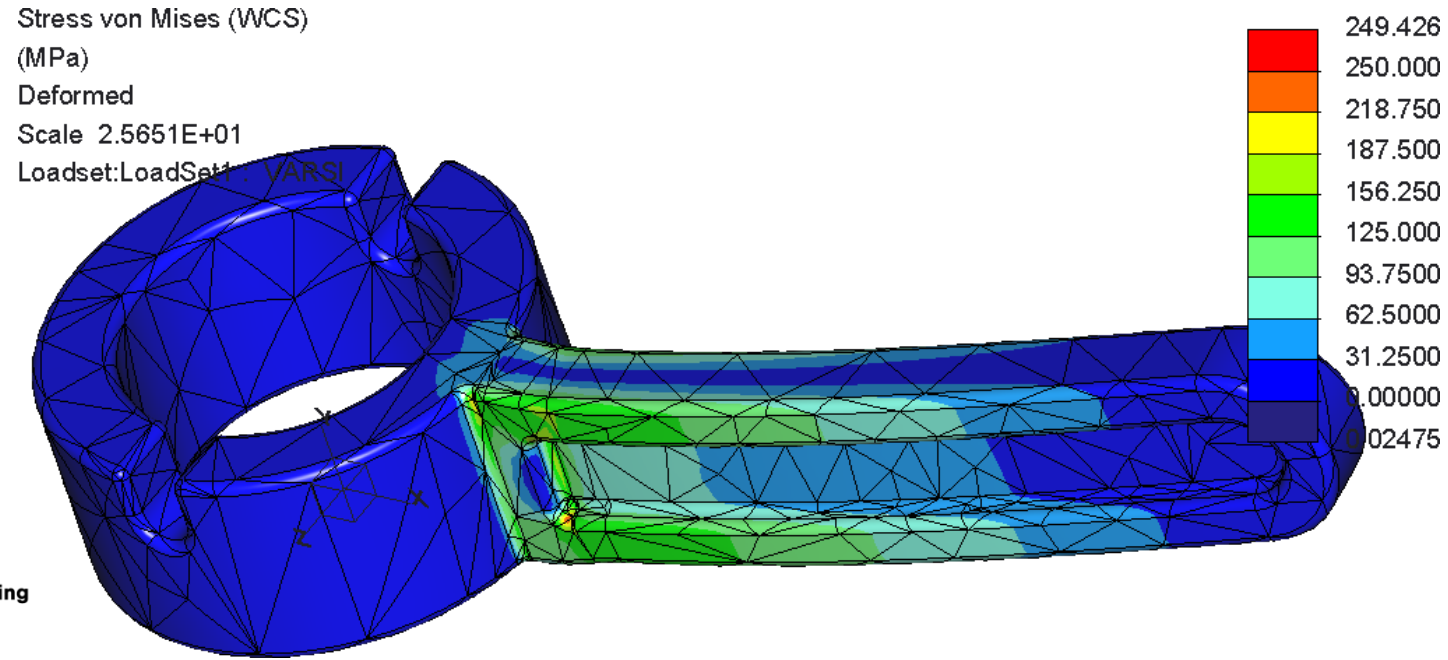
Complex geometry

Material steel, 250 N force, fixed on left



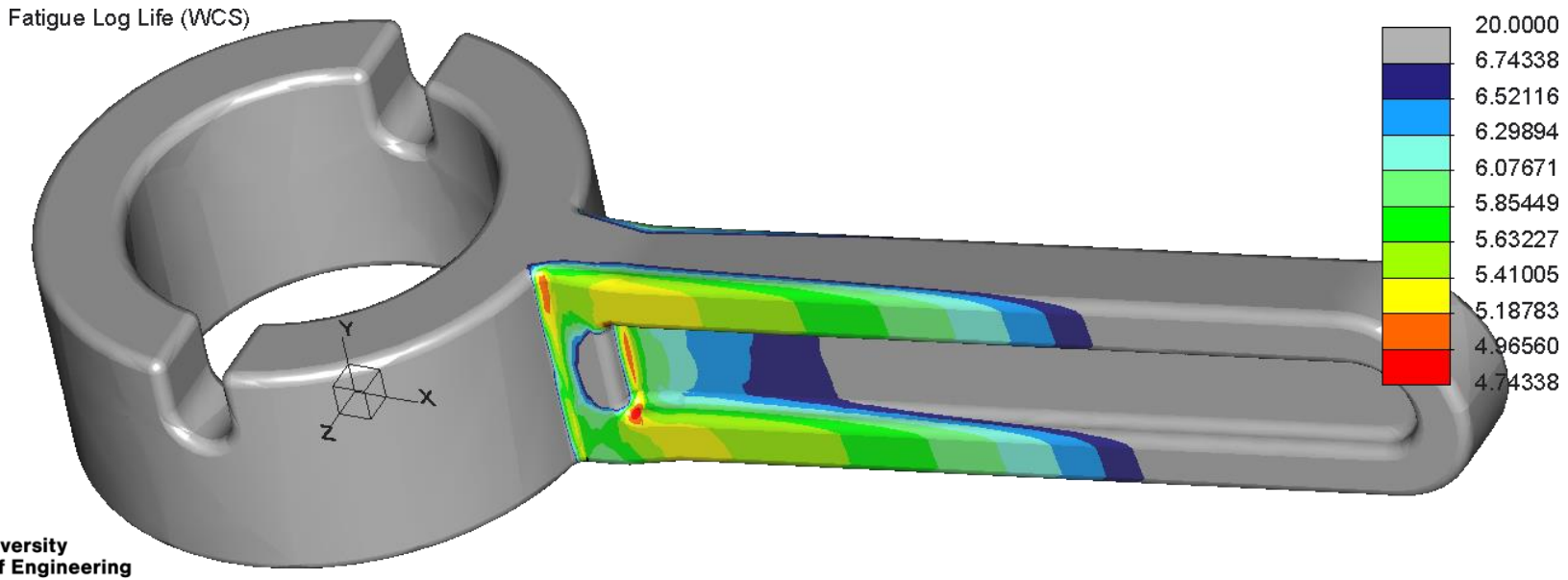
Complex geometry - Results

Stresses under 250 MPa → OK

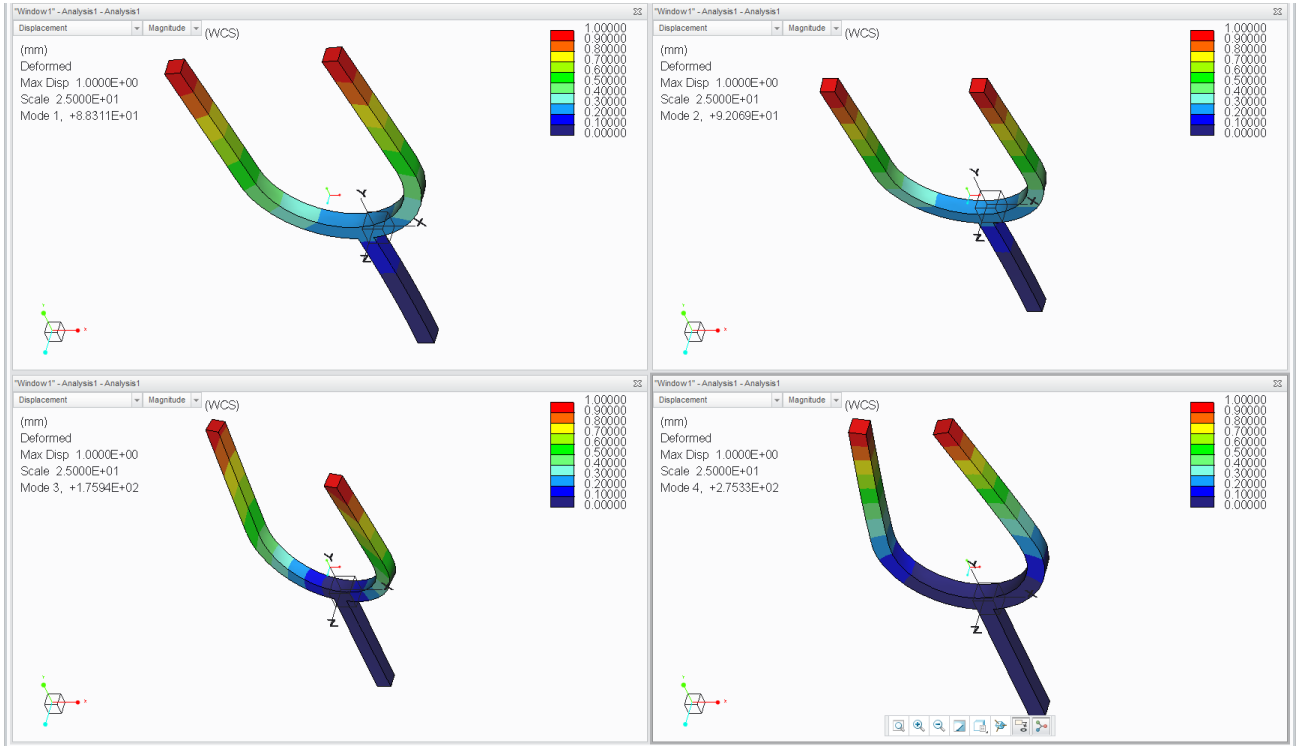


Complex geometry - Fatique

With 250 MPa max stress 10^4,7 ~ 50000 repeats



Vibration simulations



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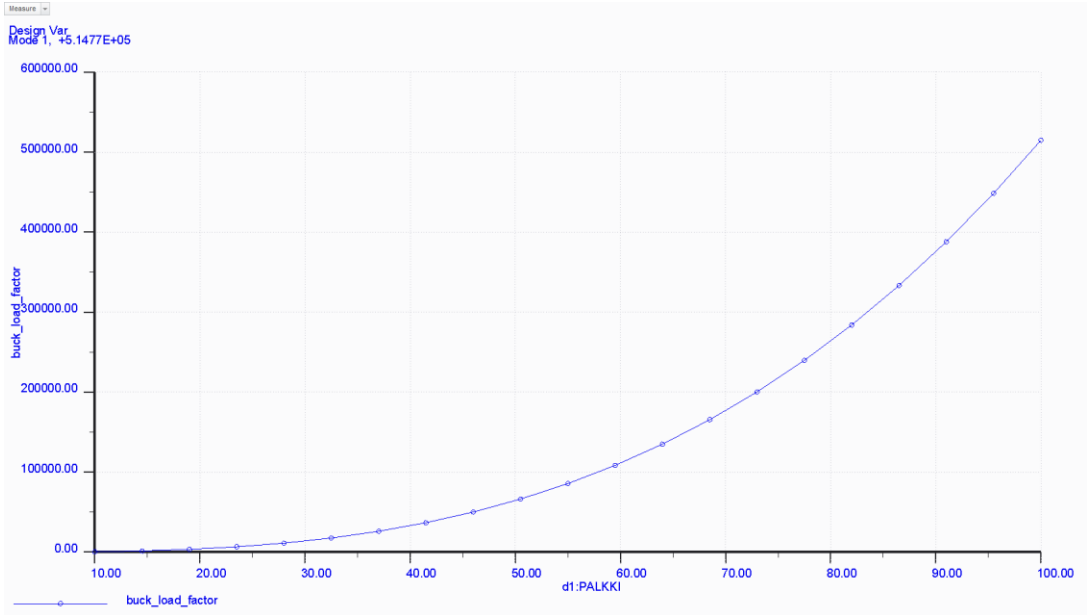
Feasibility Study

Can be used to analyze how changes in certain inputs affect the output



Optimization

Variables

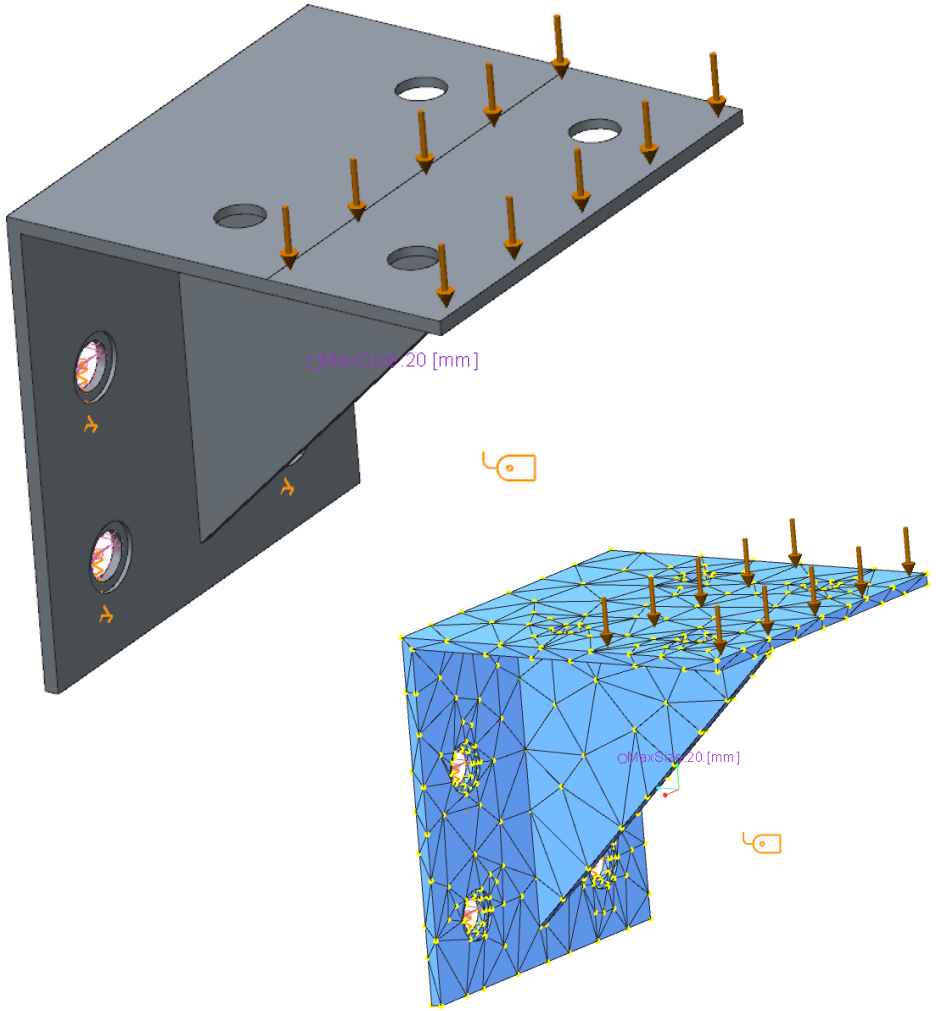
- Main thickness (1 - 5 mm)
- Rib thickness (1 - 5 mm)

Constraint

- Stress less than 250 MPa

Goal

- Minimize mass



Example Software

Stand-alone

- Abaqus
- Ansys
- Comsol
- Femap

Integrated into CAD for ex.

- Creo Simulate
- Catia Simulia
- NX Nastran

Thermal Simulations

Thermal Simulation Case

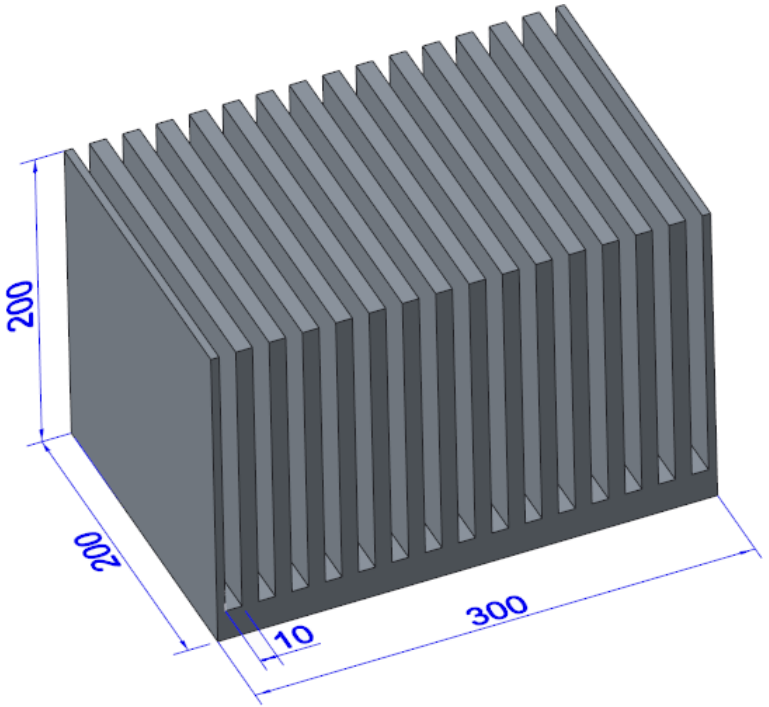
Case cooling rib

Material steel

150 W load at the bottom

No airflow

- Conduction
- Radiation



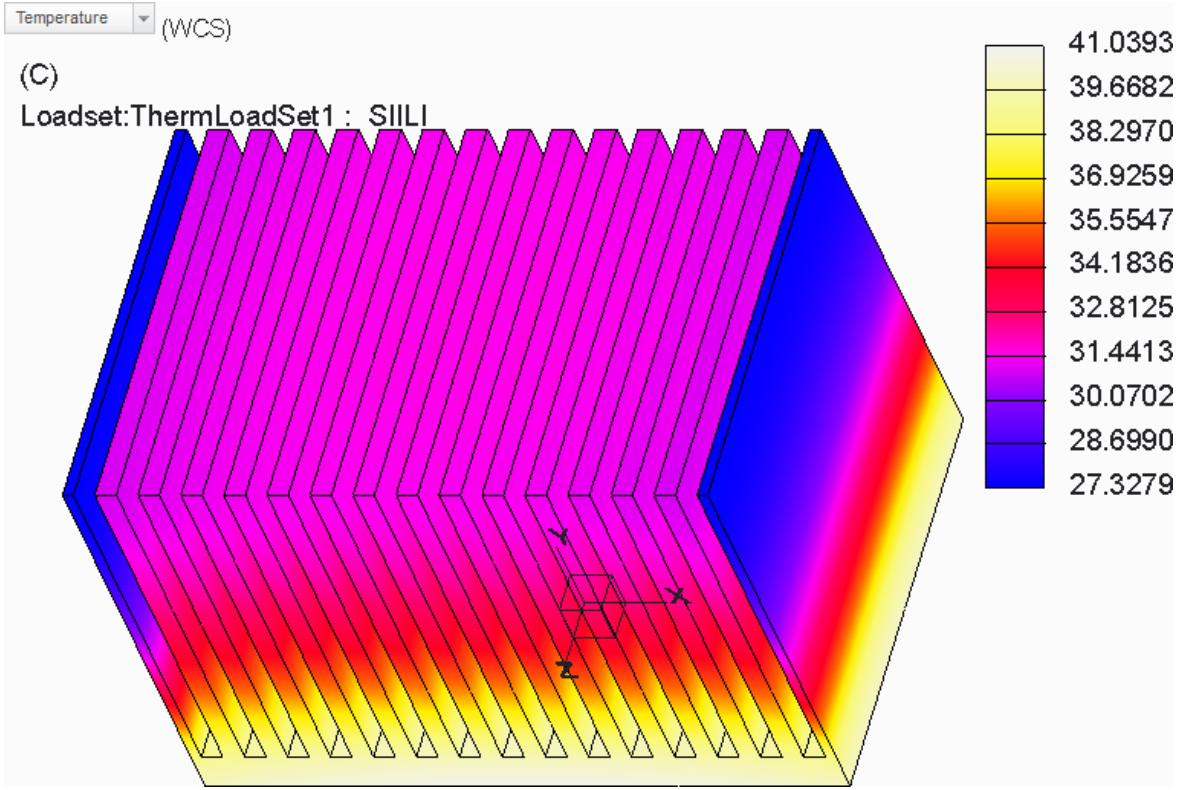
Thermal Simulation Case

10 mm ribs

Max T 41,0 °C

Only conduction

- Steel-to-air

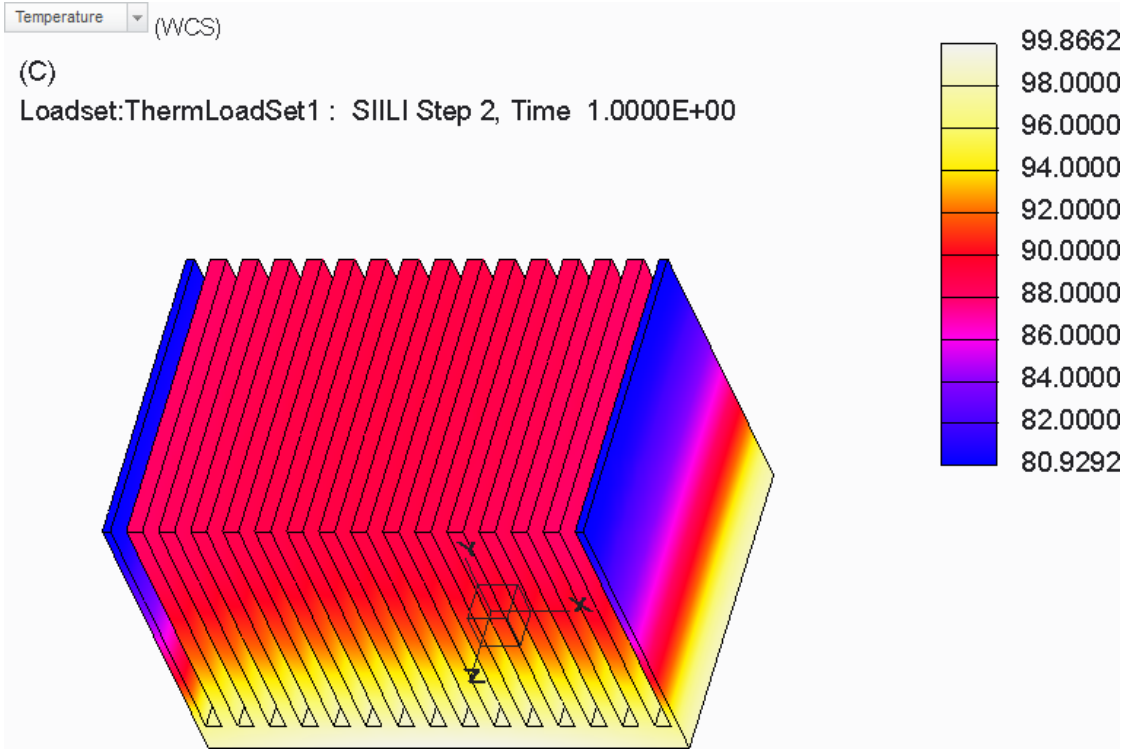


Thermal Simulation Case

10 mm ribs

Max T 99,9 °C

Only radiation



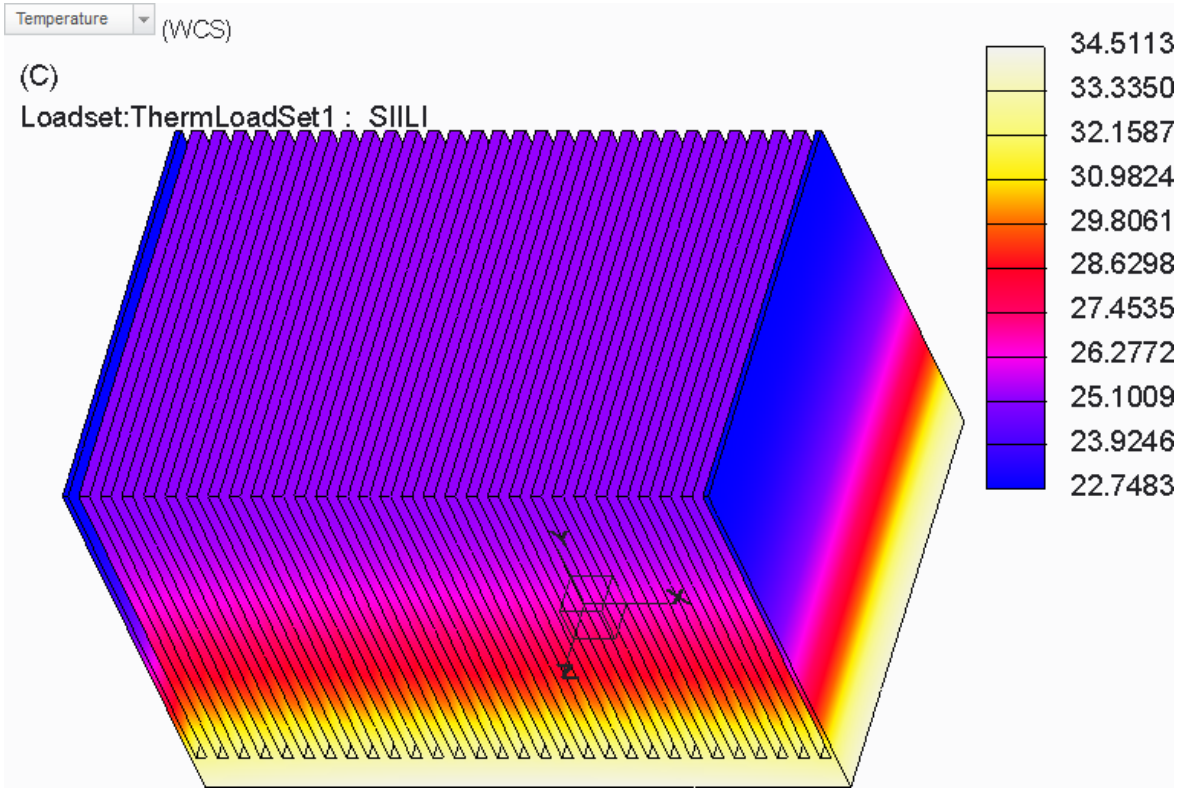
Thermal Simulation Case

5 mm ribs

Max T 35,5 °C

Only conduction

- Steel-to-air

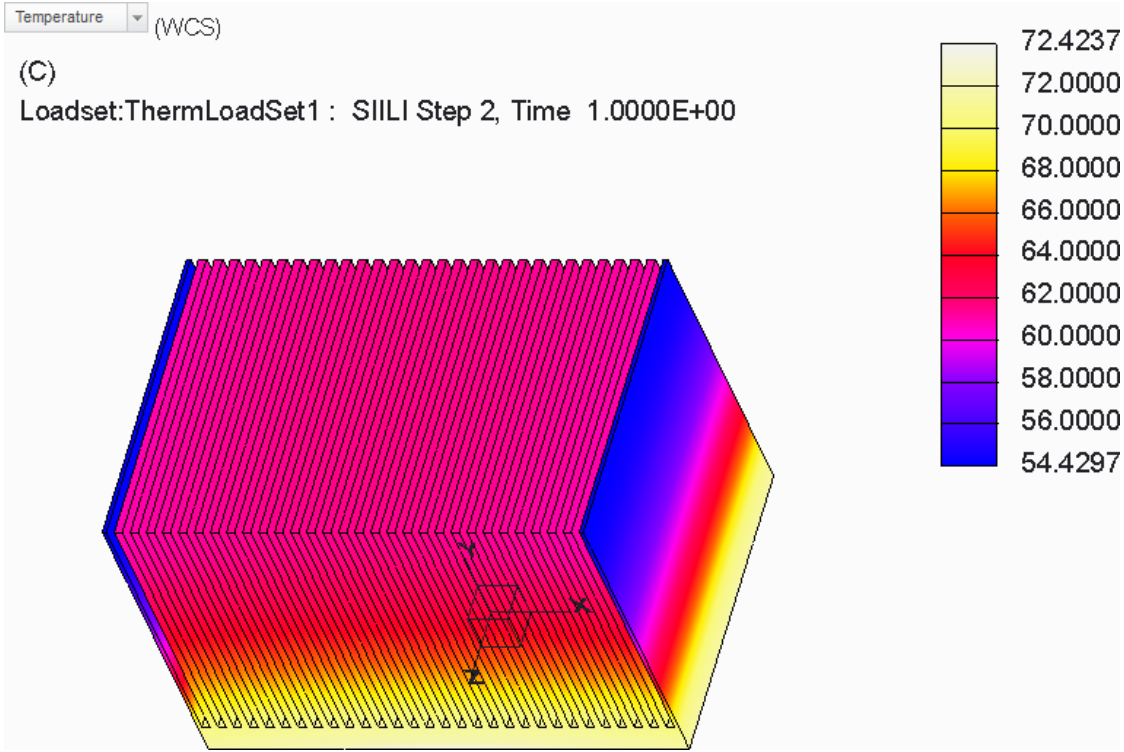


Thermal Simulation Case

5 mm ribs

Max T 72,4 °C

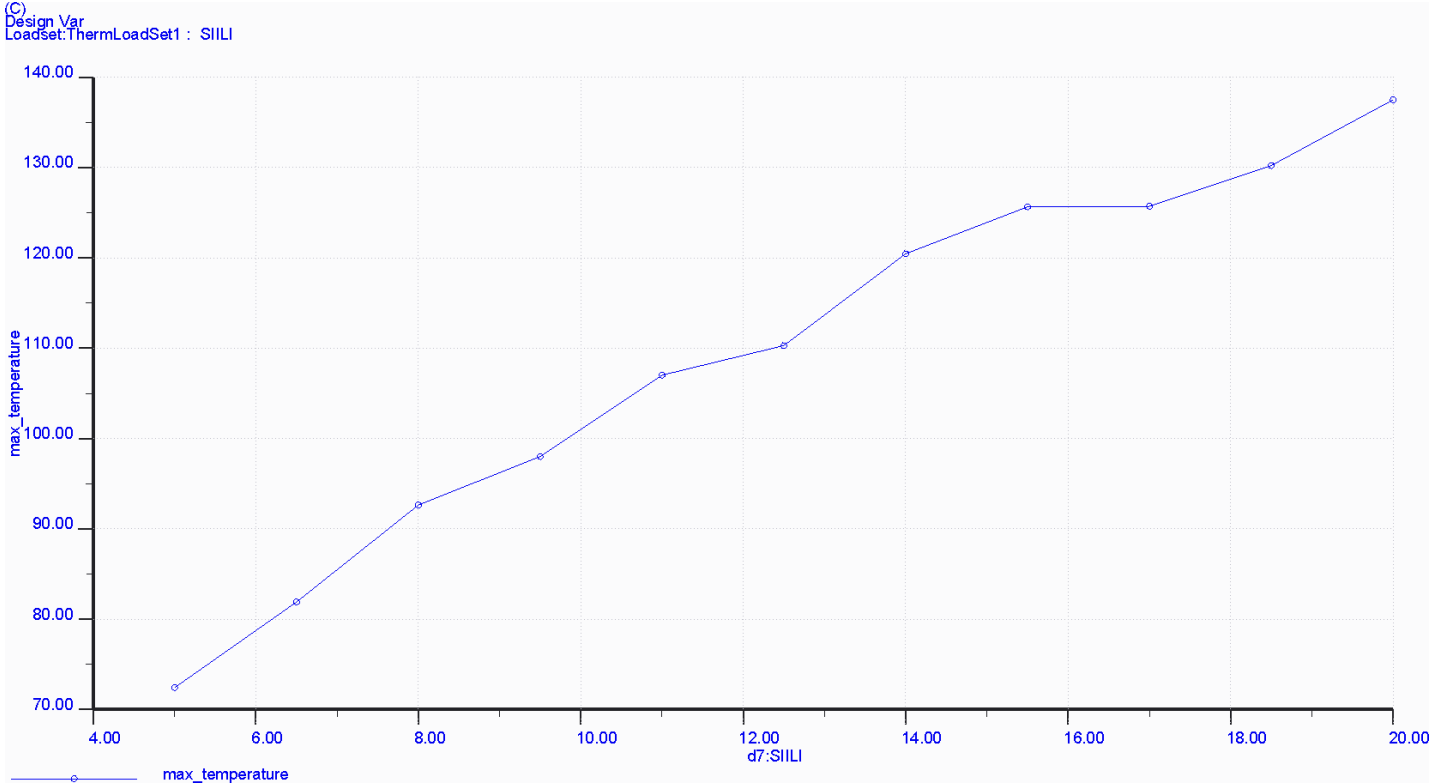
Only radiation



Feasibility Study

Rib thickness as input between 5…20 mm

Radiation



Final Words

Engineer’s Responsibility

Crap in → Crap out

If simulation model inputs are incorrect → result is also

Use your time to validate your model

- Colorful picture itself isn’t any result

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