Transient thermal analysis in Ansys: Tea cup example

Pavel Tomšič, University of Ljubljana, Slovenia

07/2021

Univerza v Ljubljani

TU WIEN TECHNISCHE UNIVERSITÄT WIEN

CINECA consorzio interuniversitario

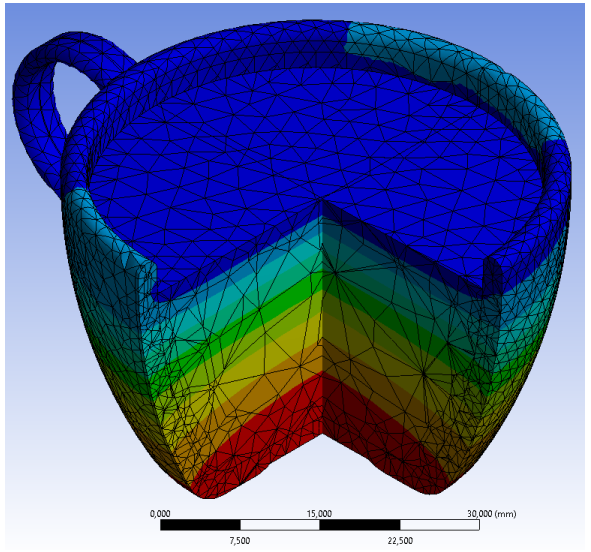
VSB TECHNICAL UNIVERSITY OF OSTRAVA | IT4INNOVATIONS NATIONAL SUPERCOMPUTING CENTER

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with support from the European Commission.
This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

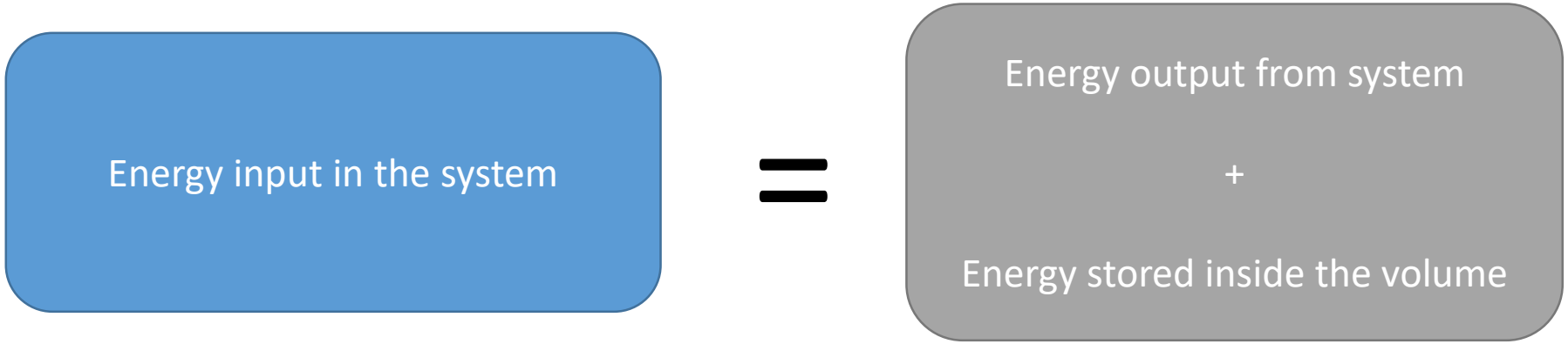
Transient analysis

- the evaluation of how a system responds to fixed and varying boundary conditions over time.
  - For fixed boundary conditions; the time to reach a steady state temperature.
  - For time-varying boundary conditions; can show the resulting thermal response.
- Many heat transfer applications involve transient thermal analyses:
  - Heat treatment problems
  - Electronic package design
  - Nozzles
  - Engine blocks
  - Pressure vessels



Transient analysis

- Thermodynamics: the principle of energy conservation



$\sum_k E_k$=constant

Transient analysis

- heat conduction through a solid:

$$k\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}\right)+q=\rho c\frac{\partial T}{\partial t}$$

Transient Term

$$k\nabla^2 T+q=\rho c\frac{\partial T}{\partial t}$$

heat conduction

heat flux/convection/ radiation/internal heat generation inside the volume

Energy stored inside the volume

k= Thermal conductivity $[W/K{\cdot}m]$
t= Time$T$= Temperature $[K]$
q= Rate of heat flux/convection/ radiation/internal heat generation inside the volume $[W]$
ρ= Density of the material $[kg/m3]$
c= Specific heat of the material $[J/kg{\cdot}K]$

Transient analysis

- Initial temperatures
  - A transient thermal analysis involves loads that are functions of time.
  - The first step in applying transient thermal loads is to establish the initial temperature distribution at time = 0.
  - Initial temperatures do not matter in steady-state analyses.
  - Initial temperatures are very important in transient analyses.
  - Leaving ice water and hot tea in the sun for 5 mins, the final temperatures will be different.

Transient analysis

- Thermal Capacitance
  - The product of density (ρ), specific heat (c) and volume (V) for a body is the **thermal capacitance** (C).
  - We can call the product $\boldsymbol{\rho c}$ the **thermal capacitance term**, which indicates the ability of the body to store thermal energy.
  - The larger the thermal capacitance term, the more time it will take to heat the body and vice-versa.

thermal capacitance term

$$k\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}\right)+q=\rho c\frac{\partial T}{\partial t}$$

  - In matrix form the transient thermal heat conduction can be written as:

$$C\{\dot{T}\}+K\{T\}=Q\{t\}$$

Thermal Capacitance Matrix — Thermal Conductivity Matrix — Heat Rate Vector

Before we start

- Login to NoMachine

- Copy files for the analysis

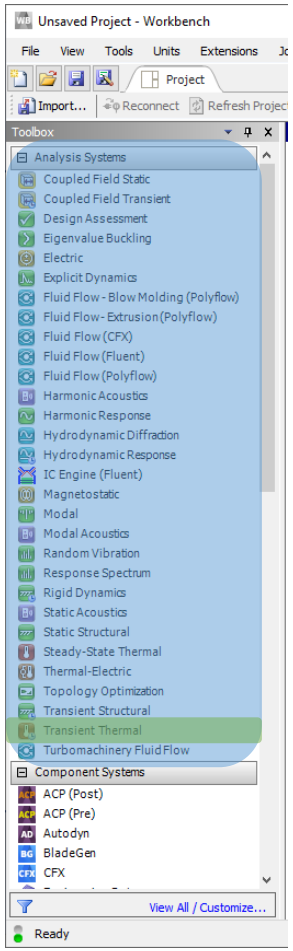
```
cp -R /tmp/sctrain_cases_day4 ./
```

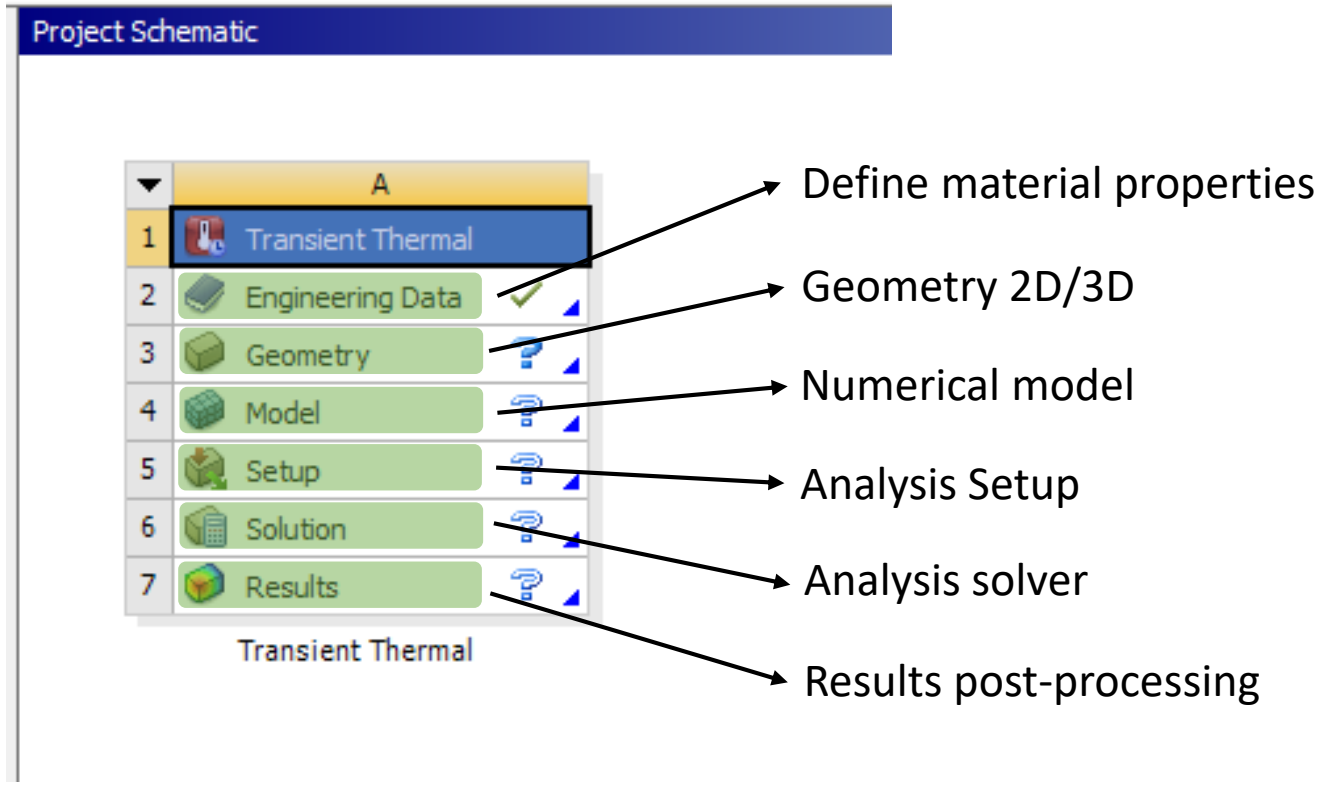
- Open Ansys

```
[user@viz ~]$ module load ANSYS
[user@viz ~]$ runwb2
```

Analysis setting

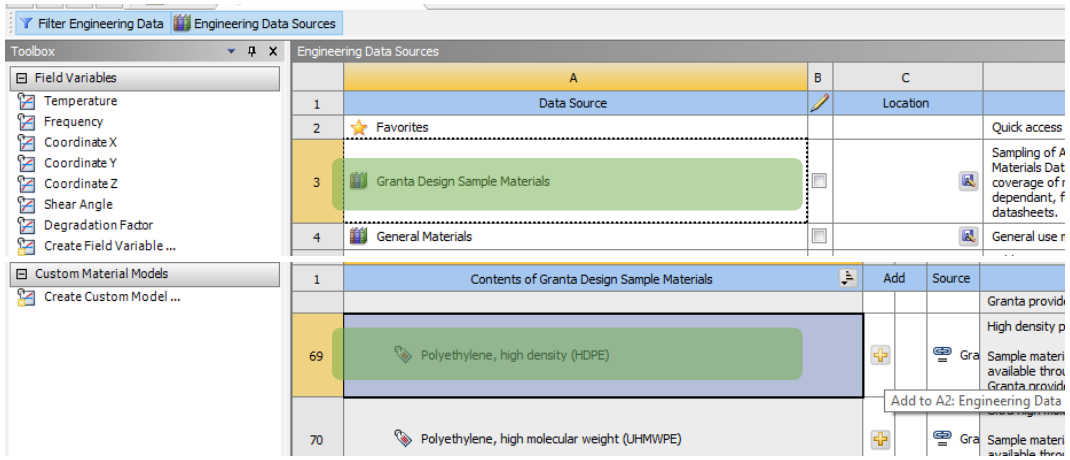
Choose Transient Thermal analysis



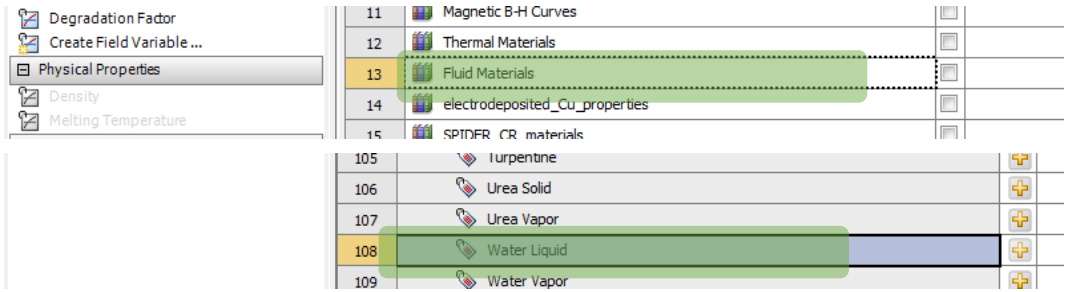


Defining the material

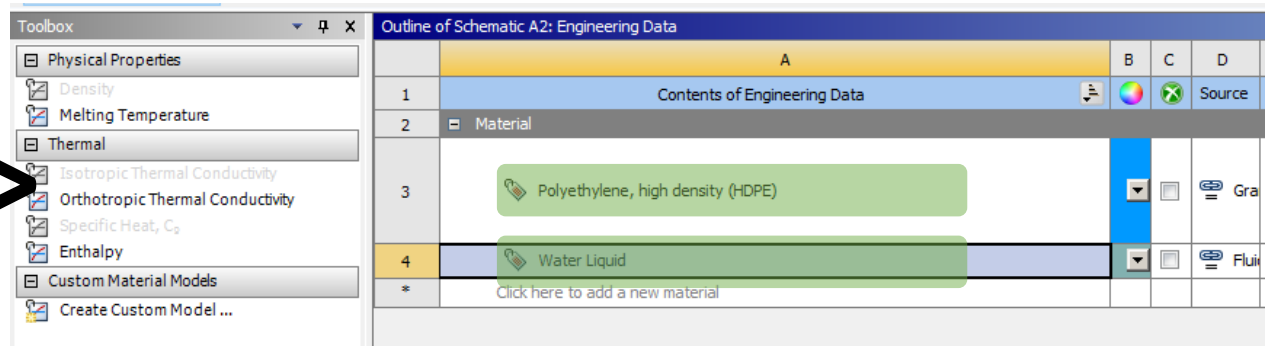
SCtrain | SUPERCOMPUTING KNOWLEDGE PARTNERSHIP



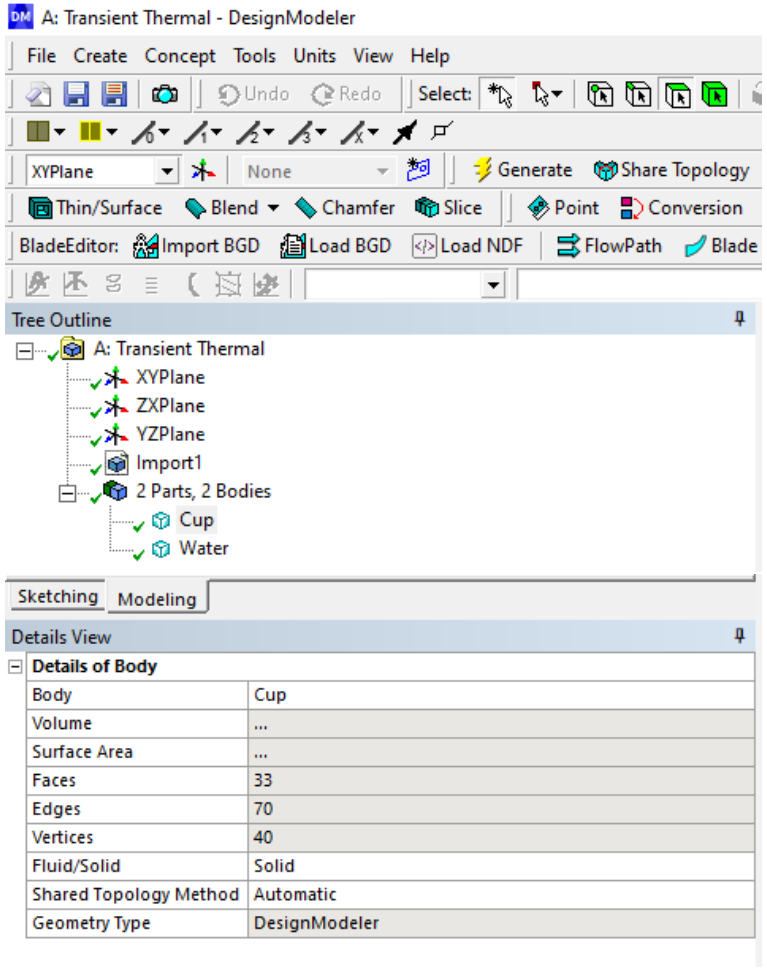
+

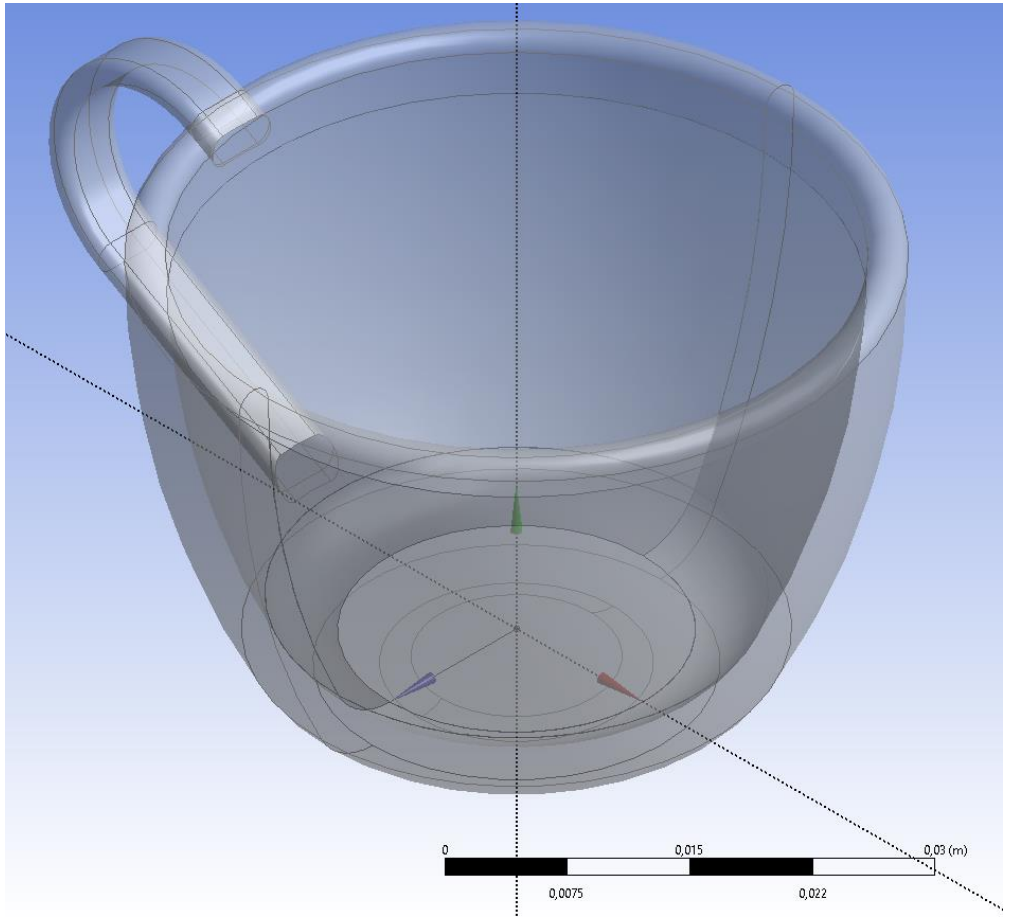


=>

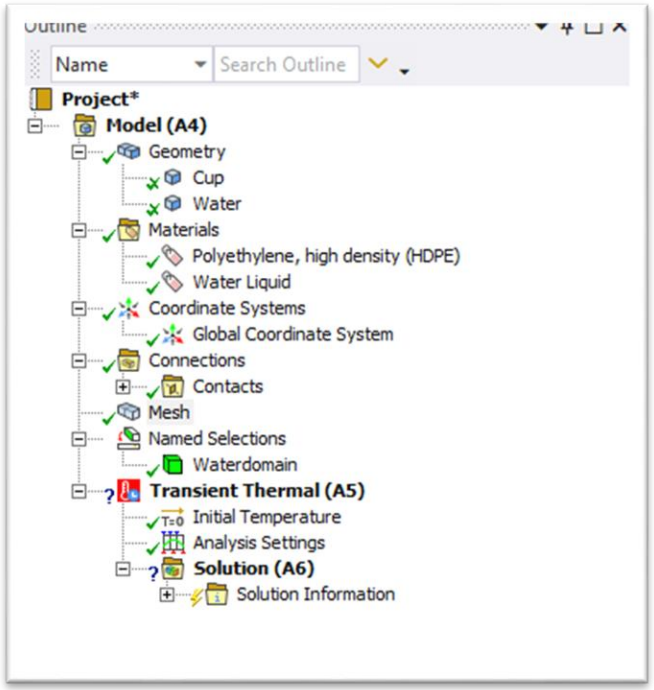


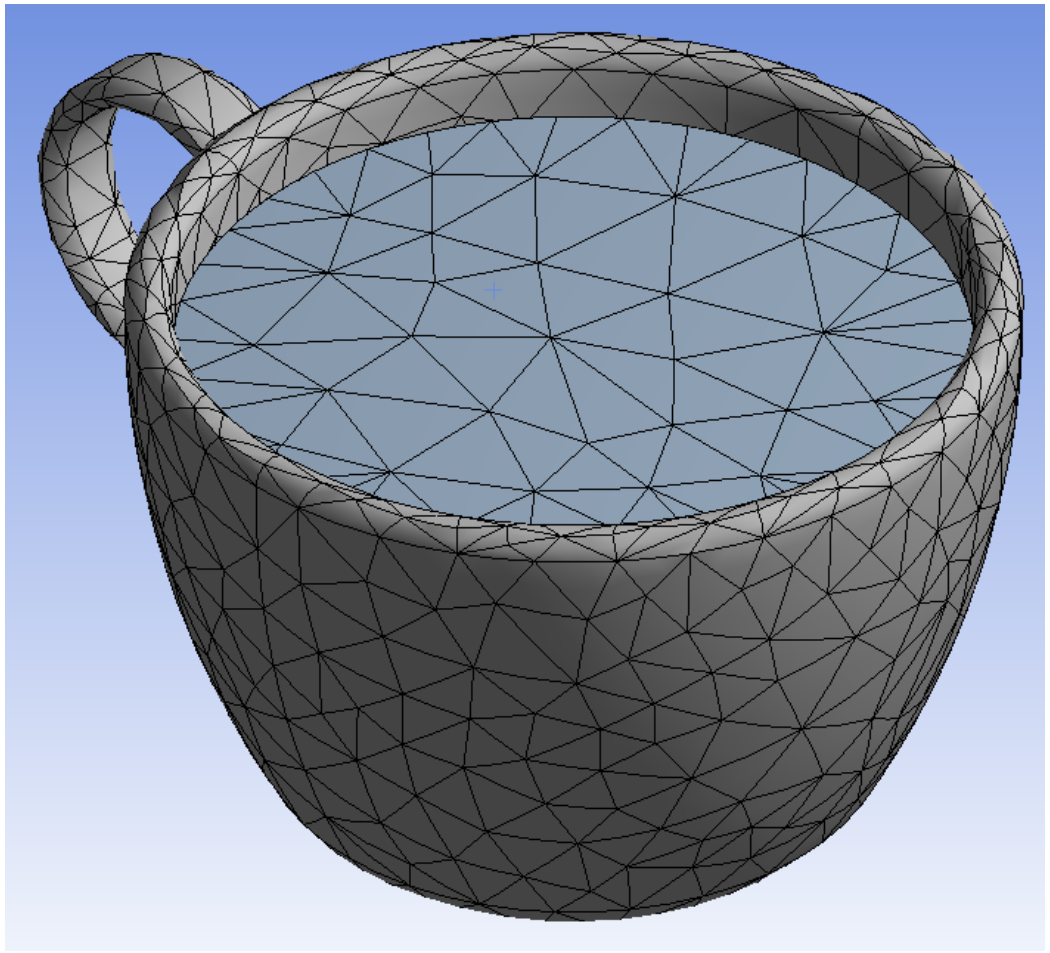
Geometry


A: Transient Thermal - DesignModeler
File Create Concept Tools Units View Help
Undo Redo Select:
XYPlane None Generate Share Topology
Thin/Surface Blend Chamfer Slice Point Conversion
BladeEditor: Import BGD Load BGD Load NDF FlowPath Blade
Tree Outline
A: Transient Thermal
XYPlane
ZXPlane
YZPlane
Import1
2 Parts, 2 Bodies
Cup
Water
Sketching Modeling
Details View
Details of Body
Body Cup
Volume ...
Surface Area ...
Faces 33
Edges 70
Vertices 40
Fluid/Solid Solid
Shared Topology Method Automatic
Geometry Type DesignModeler


0
0,015
0,03 (m)
0,0075
0,022

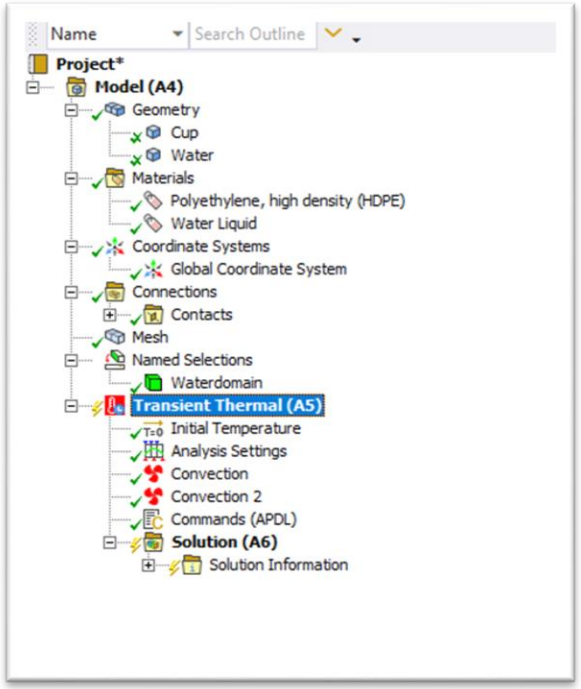
Numerical model

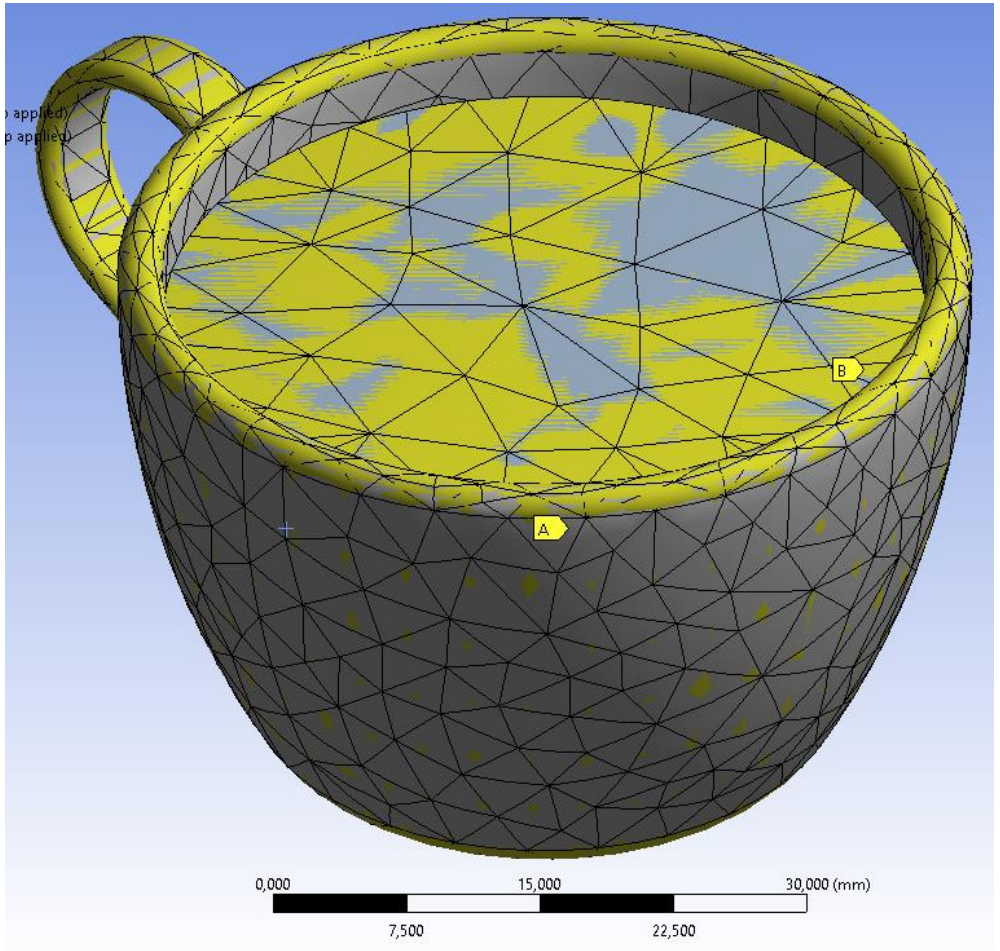




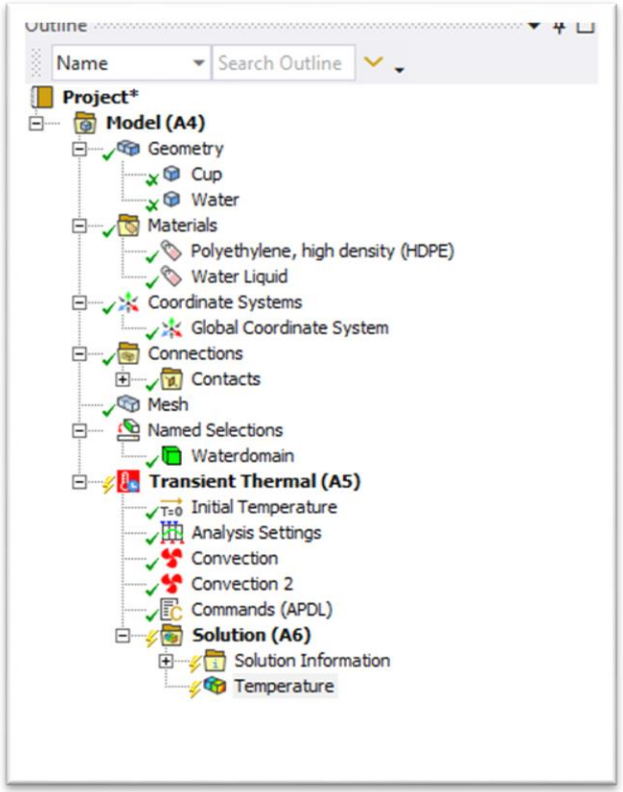
Analysis setup

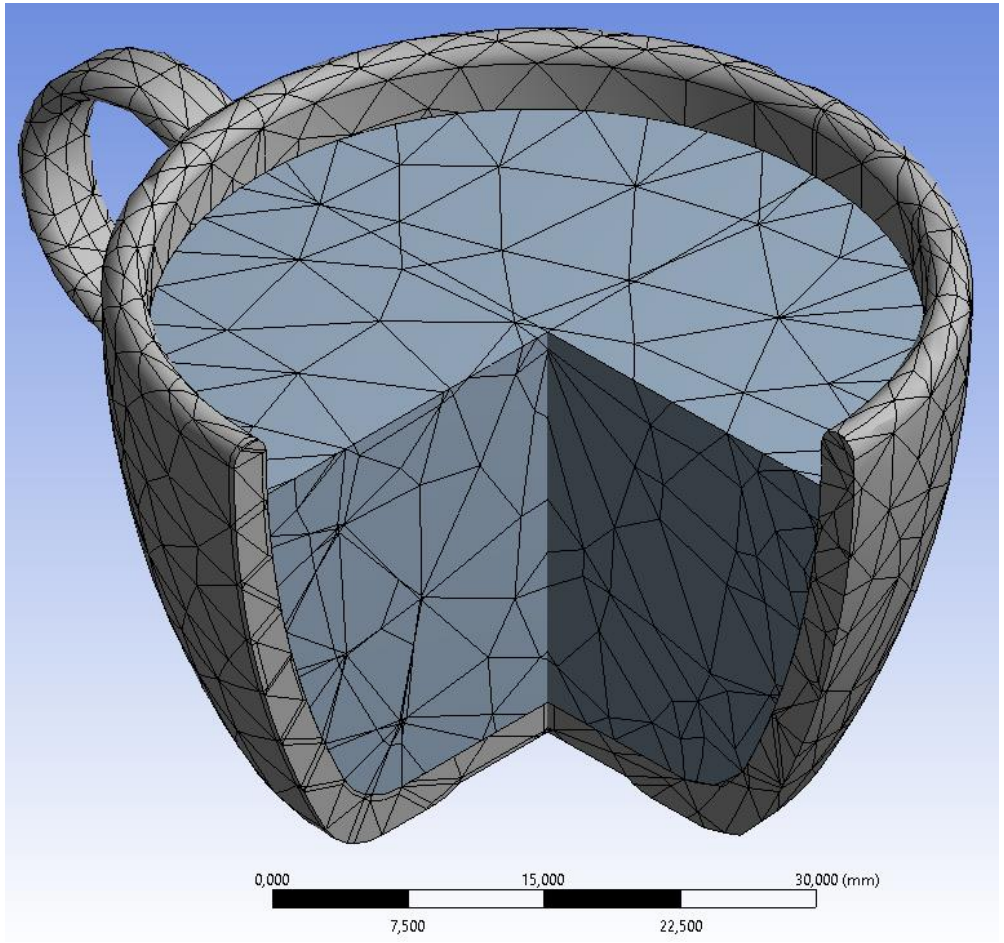
IC,Waterdomain,TEMP,90



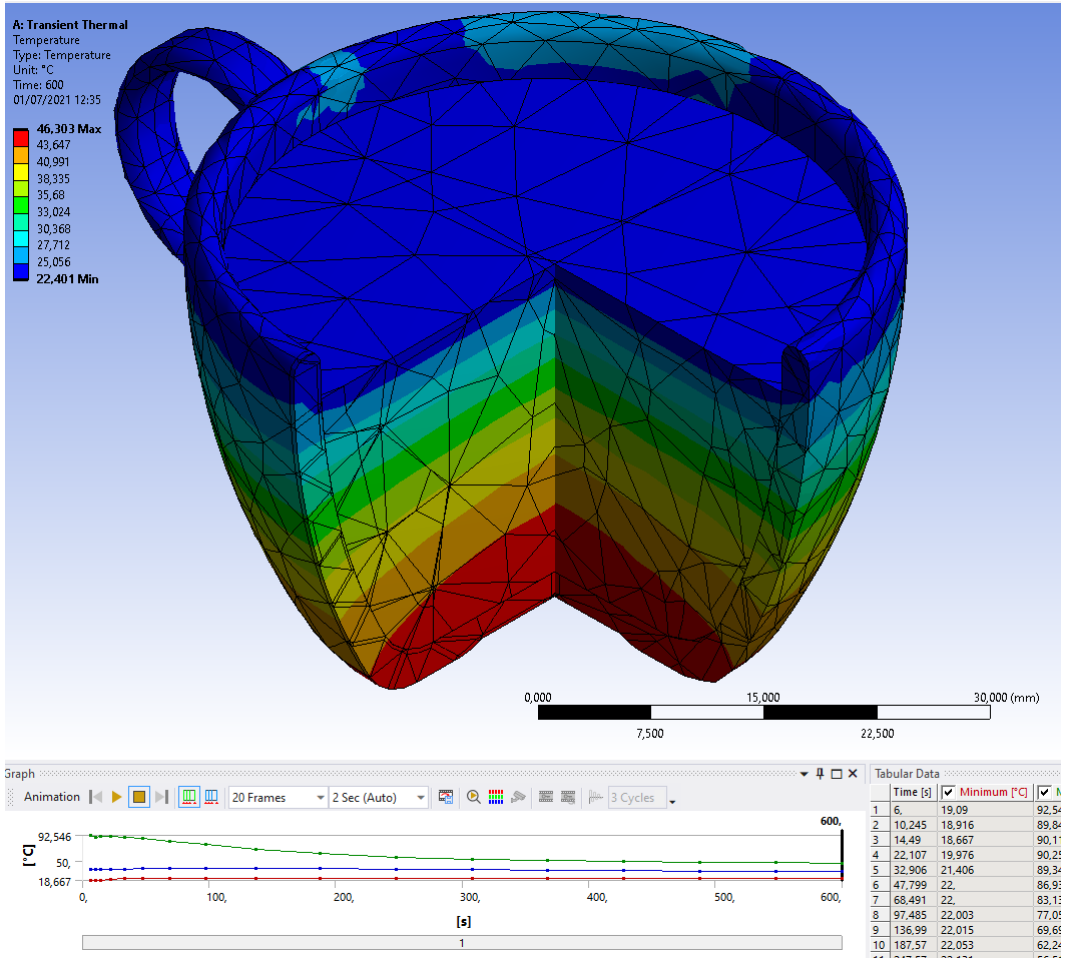


Post processing setup



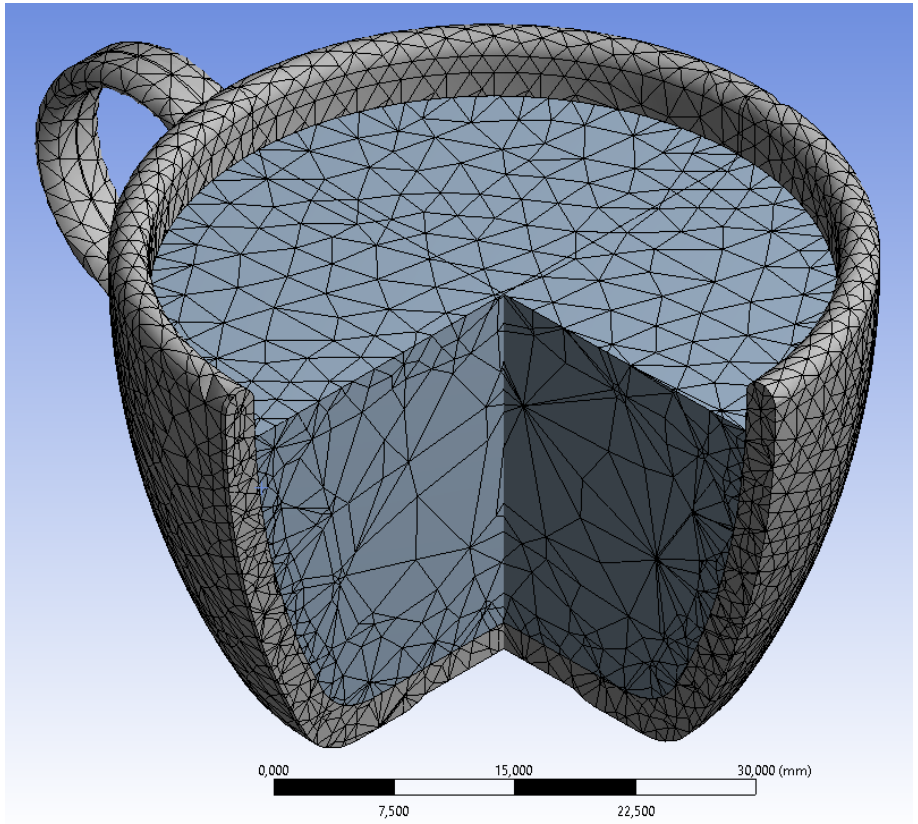


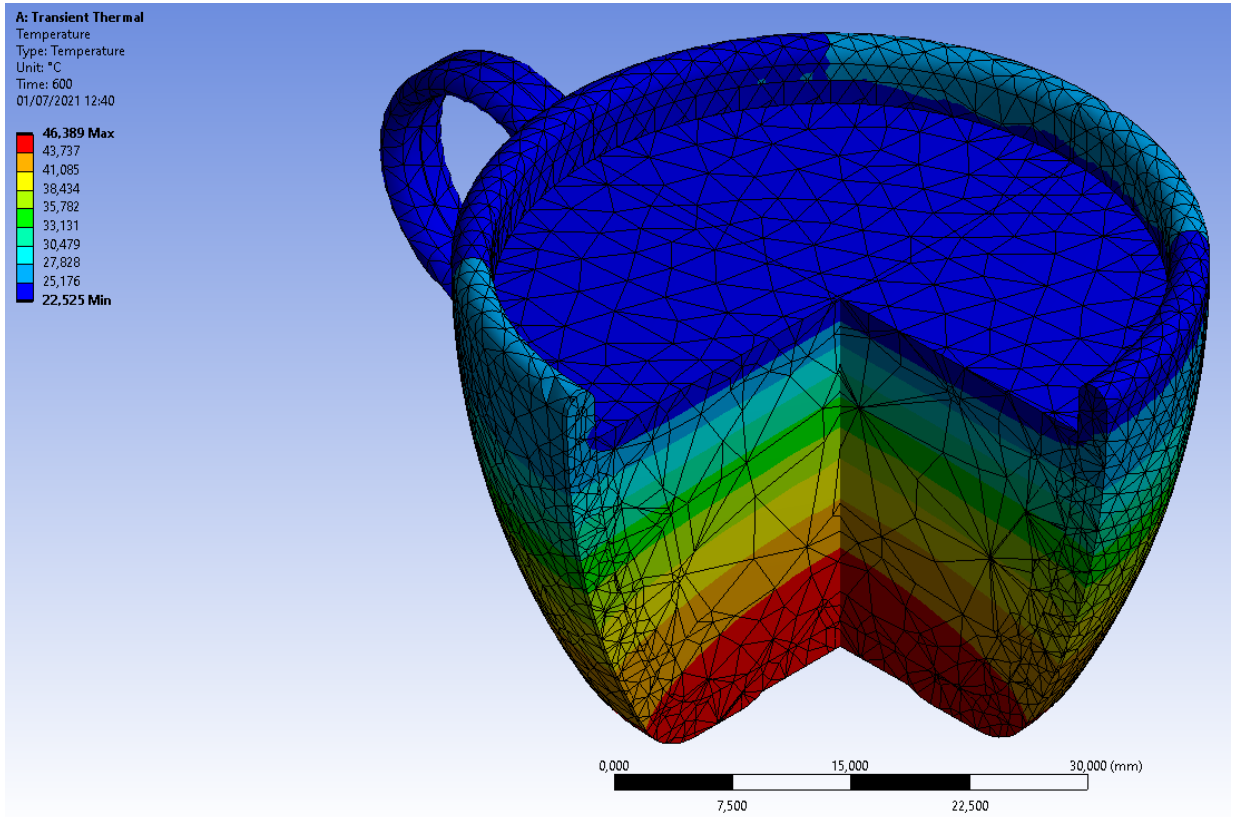
Post processing



Changing the mesh element size

Element size: 1,5mm

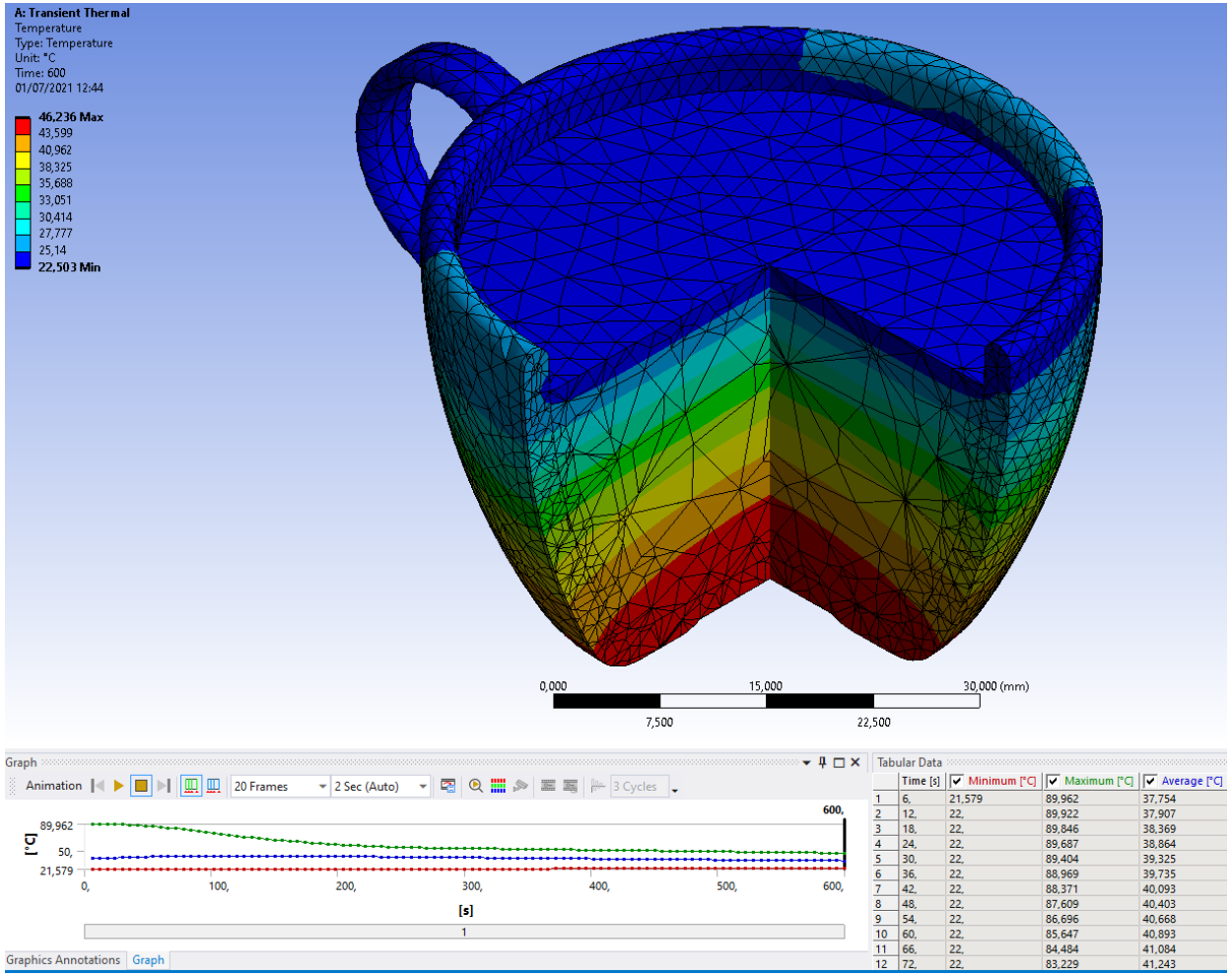




Changing the time step

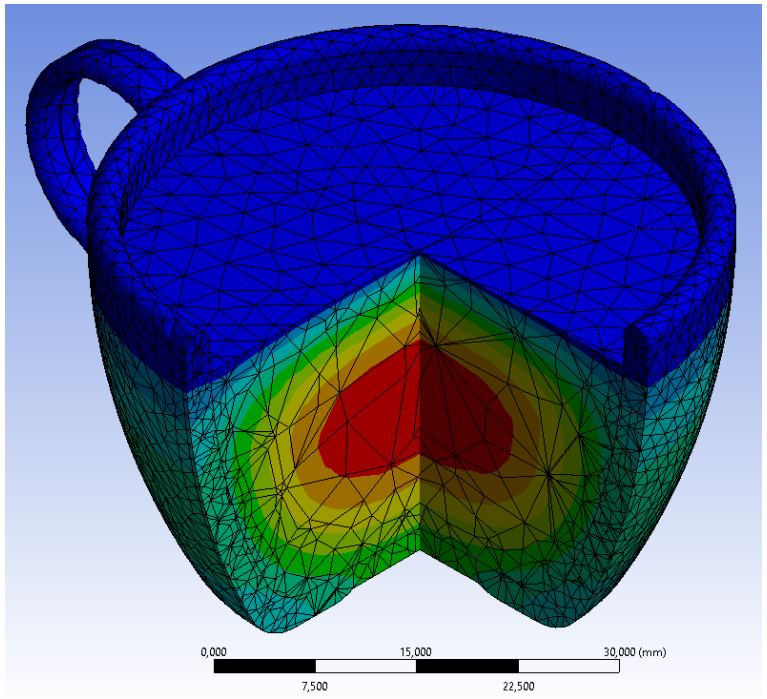
SCtrain | SUPERCOMPUTING KNOWLEDGE PARTNERSHIP

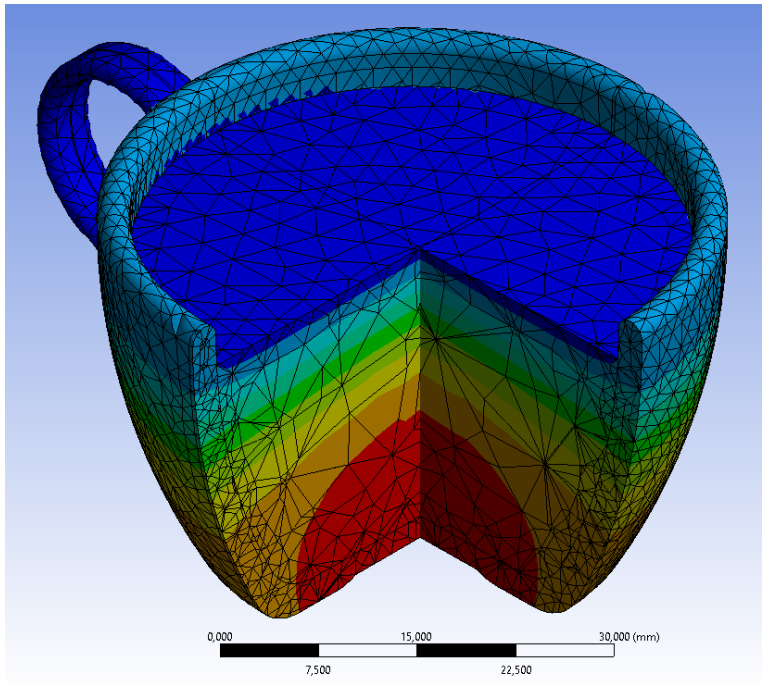
Timestep: 6 sec

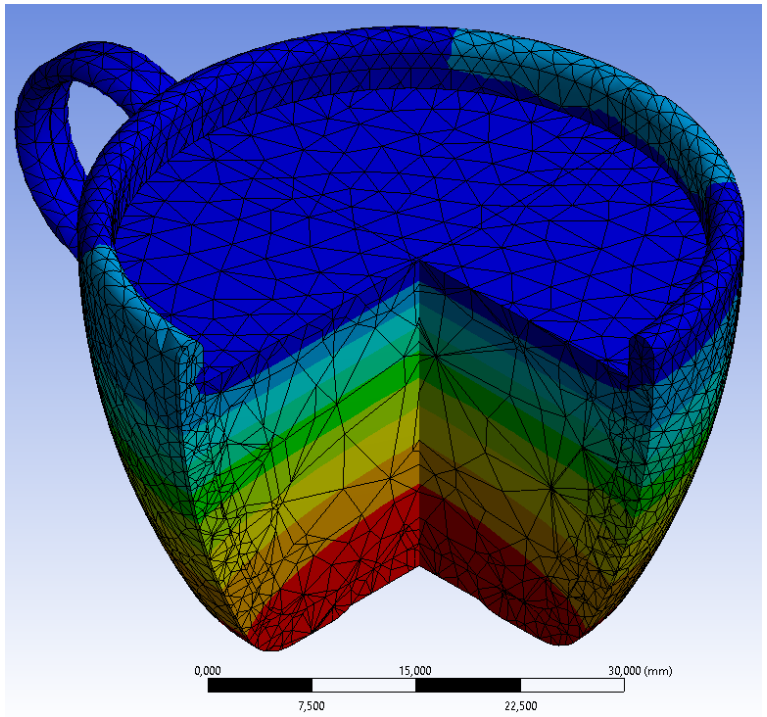


Your changes

- Better mesh?
- Timestep?







Thank you for your attention!

http://sctrain.eu/

Univerza v Ljubljani

TU WIEN TECHNISCHE UNIVERSITÄT WIEN

CINECA consorzio interuniversitario

VSB TECHNICAL UNIVERSITY OF OSTRAVA | IT4INNOVATIONS NATIONAL SUPERCOMPUTING CENTER

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with support from the European Commission.
This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.