



Primer tranzientne analize

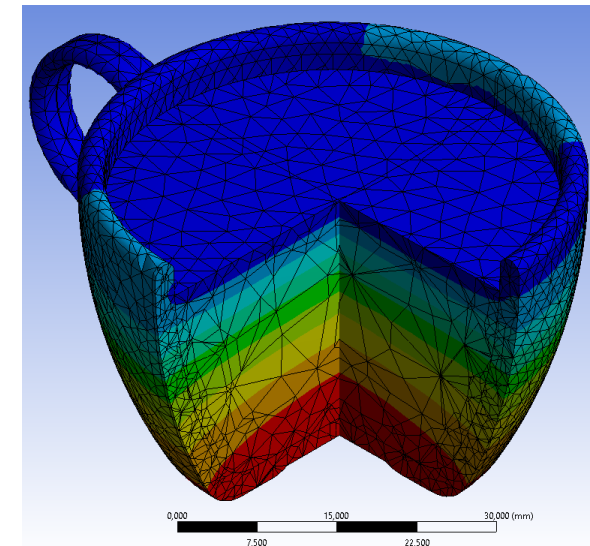
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11-02-2022

Transient analysis



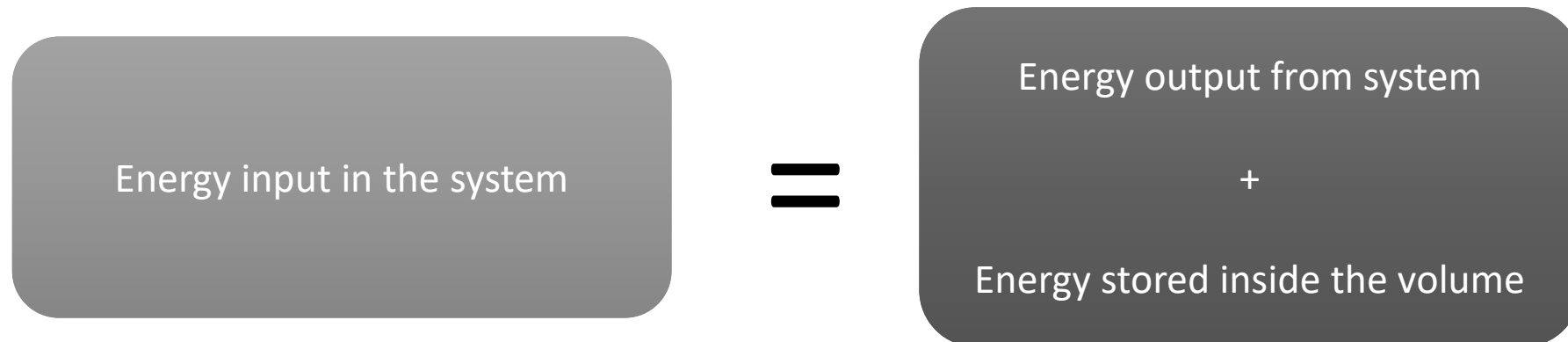
- the evaluation of how a system responds to fixed and varying boundary conditions over time.
 - For fixed boundary conditions; the time to reach a steady state temperature.
 - For time-varying boundary conditions; can show the resulting thermal response.
- Many heat transfer applications involve transient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



Transient analysis



- Thermodynamics: the principle of energy conservation



$$\sum_k E_k = \text{constant}$$

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/m^3]
 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 ρc 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.

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

thermal capacitance term

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

$$\begin{array}{ccc} & C\{\dot{T}\} + K\{T\} = Q\{t\} & \\ \swarrow & & \searrow \\ \text{Thermal Capacitance Matrix} & \text{Thermal Conductivity Matrix} & \text{Heat Rate Vector} \end{array}$$

Before we start



- Login to NoMachine
- Copy files for the analysis

```
cp -R /tmp/EuroCC_HPC_FEM/Day_3 ./
```

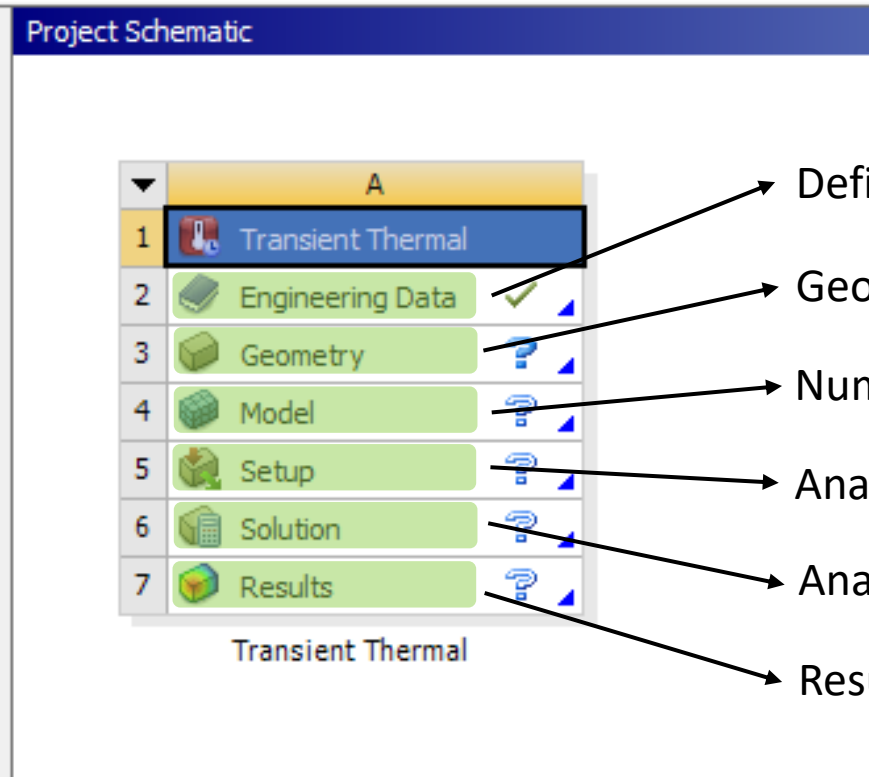
- Open Ansys

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

Analysis setting



Choose Transient Thermal analysis



Defining the material



Filter Engineering Data | Engineering Data Sources

| Toolbox | | Engineering Data Sources | | |
|---------|----|--|-----|---|
| | A | B | C | |
| | 1 | Data Source | | Location |
| | 2 | ★ Favorites | | Quick access |
| | 3 | Granta Design Sample Materials | | Sampling of A Materials Data coverage of dependent, f datasheets. |
| | 4 | General Materials | | General use r |
| | 1 | Contents of Granta Design Sample Materials | Add | Source |
| | 69 | Polyethylene, high density (HDPE) | + | Granta Sample material available through Granta.provid |
| | 70 | Polyethylene, high molecular weight (UHMWPE) | + | Granta Sample material available thro |



| | | | |
|--|-----|--------------------------------|---|
| | 11 | Magnetic B-H Curves | |
| | 12 | Thermal Materials | |
| | 13 | Fluid Materials | |
| | 14 | electrodeposited_Cu_properties | |
| | 15 | SPIDFR CR materials | |
| | 105 | Turpentine | + |
| | 106 | Urea Solid | + |
| | 107 | Urea Vapor | + |
| | 108 | Water Liquid | + |
| | 109 | Water Vapor | + |



Toolbox

| |
|----------------------------------|
| Physical Properties |
| Density |
| Melting Temperature |
| Thermal |
| Isotropic Thermal Conductivity |
| Anisotropic Thermal Conductivity |
| Specific Heat, C _p |
| Enthalpy |
| Custom Material Models |
| Create Custom Model ... |

Outline of Schematic A2: Engineering Data

| A | | B | C | D |
|---|-----------------------------------|---|---|--------|
| 1 | Contents of Engineering Data | | | Source |
| 2 | Material | | | |
| 3 | Polyethylene, high density (HDPE) | | | Granta |
| 4 | Water Liquid | | | Fluid |
| * | Click here to add a new material | | | |

Geometry



DM A: Transient Thermal - DesignModeler

File Create Concept Tools Units View Help

Undo Redo Select: * [Icons]

XYPlane None Generate Share Topology

Thin/Surface Blend Chamfer Slice Point Conversion

BladeEditor: Import BGD Load BGD Load NDF FlowPath Blade

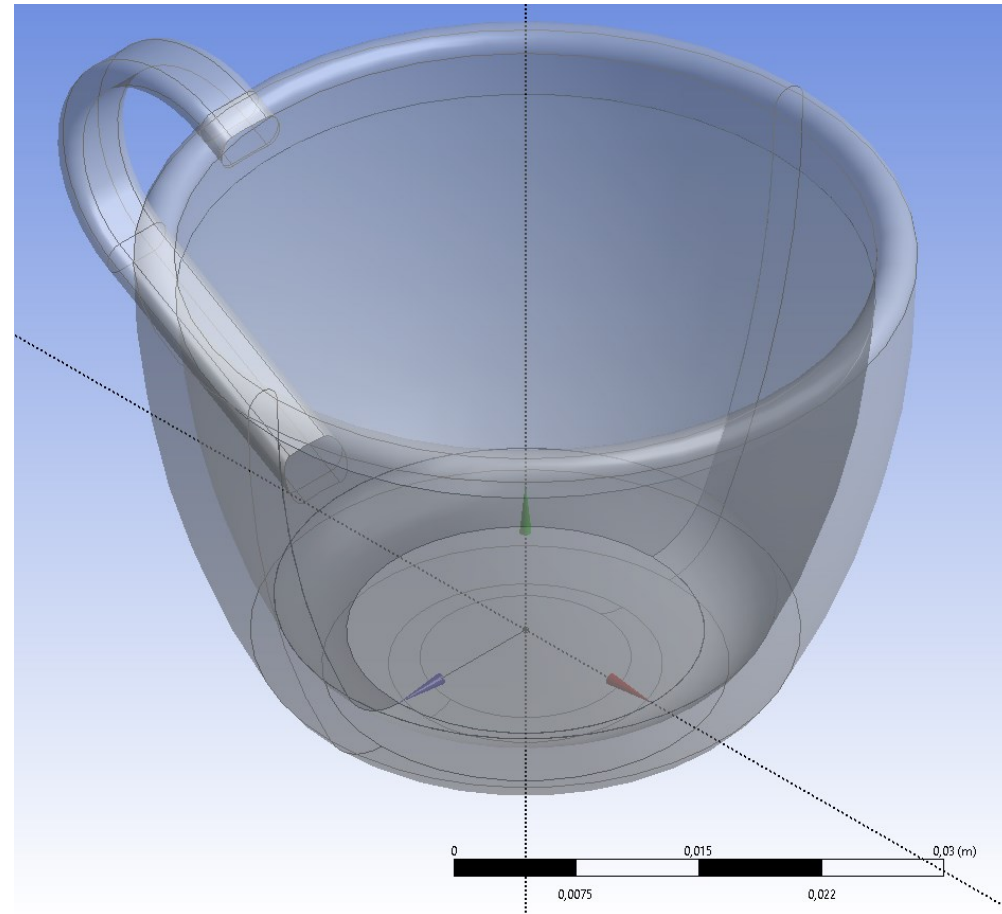
Tree Outline

- A: Transient Thermal
 - XYPlane
 - ZXPlane
 - YZPlane
 - Import1
 - 2 Parts, 2 Bodies
 - Cup
 - Water

Sketching Modeling

Details View

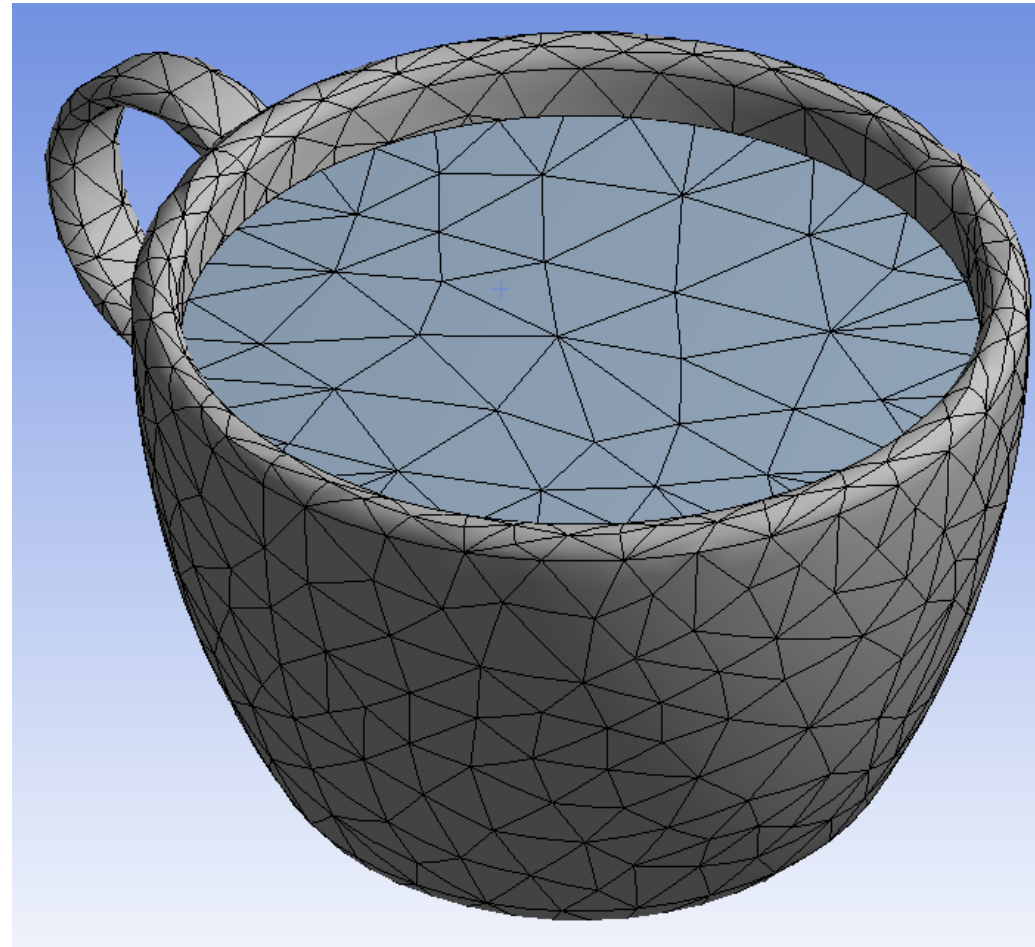
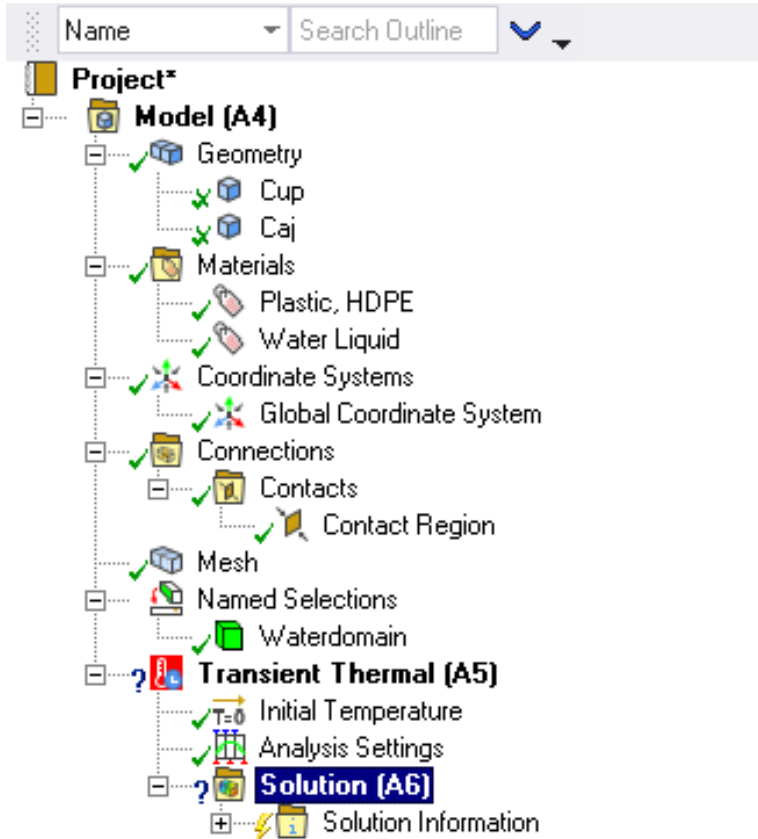
| Details of Body | |
|------------------------|---------------|
| Body | Cup |
| Volume | ... |
| Surface Area | ... |
| Faces | 33 |
| Edges | 70 |
| Vertices | 40 |
| Fluid/Solid | Solid |
| Shared Topology Method | Automatic |
| Geometry Type | DesignModeler |



Numerical model



SLING



Analysis setup



IC, Waterdomain, TEMP, 90

Outline

Name Search Outline

- Project*
 - Model (A4)
 - Geometry
 - Cup
 - Caj
 - Materials
 - Plastic, HDPE
 - Water Liquid
 - Coordinate Systems
 - Global Coordinate System
 - Connections
 - Contacts
 - Contact Region
 - Mesh
 - Named Selections
 - Waterdomain
 - Transient Thermal (A5)
 - Initial Temperature
 - Analysis Settings
 - Convection
 - Convection 2
 - Commands (APDL)
 - Solution (A6)
 - Solution Information

Import Convection Data

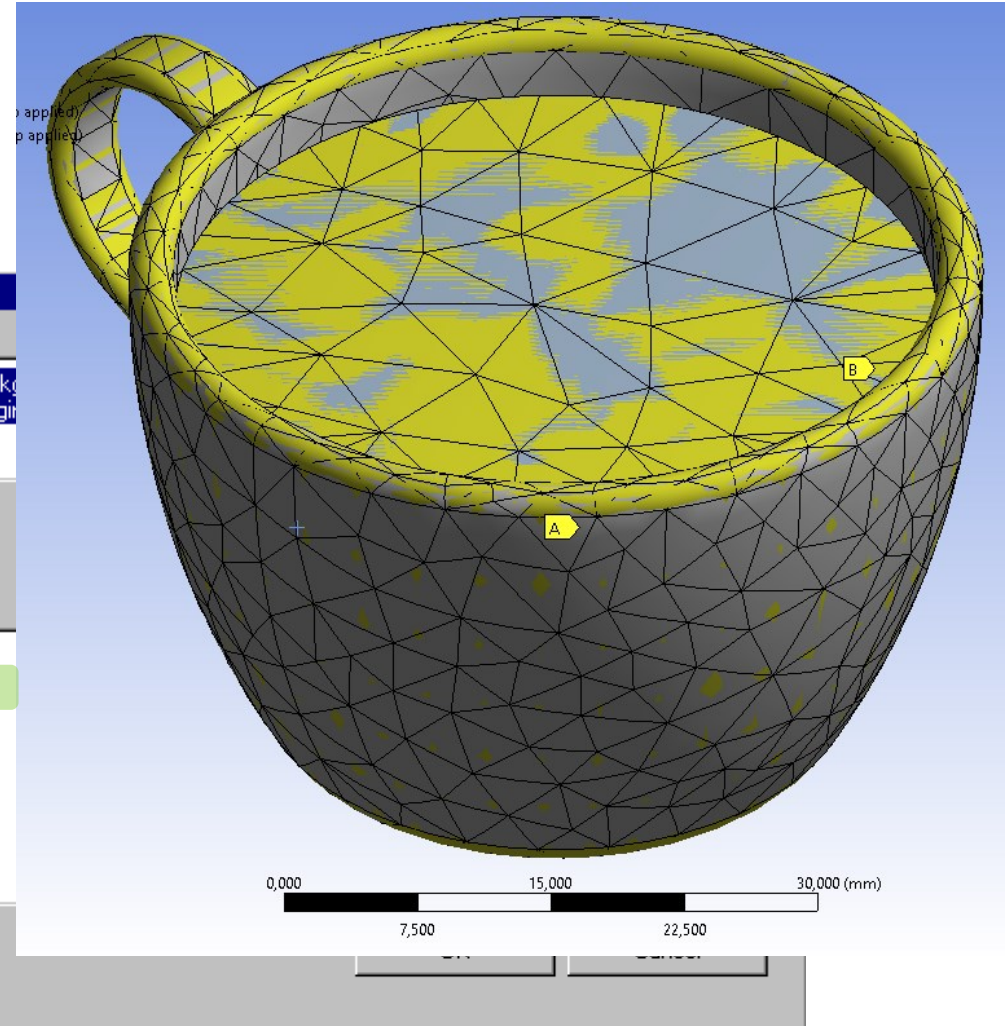
Data Source:

Convection_Samples /opt/pk... us/Engi...

Convection Data to Import:

Filter

- Stagnant Air - Horizontal Cyl
- Stagnant Air - Simplified Case
- Stagnant Air - Vertical Planes1
- Stagnant Air - Vertical Planes2
- Stagnant Air - Vertical Planes
- Stagnant Water - Simplified Case



Post processing setup



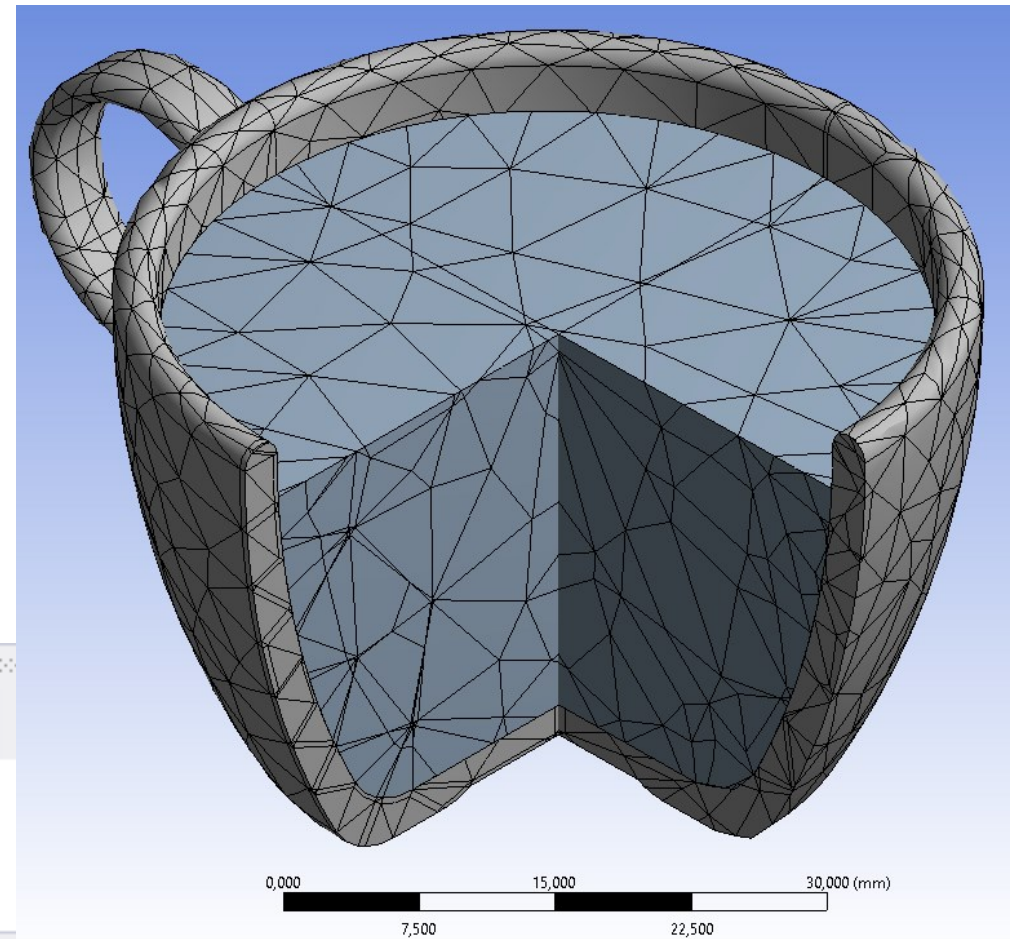
Name Search Outline

- Project*
 - Model (A4)
 - Geometry
 - Cup
 - Caj
 - Materials
 - Plastic, HDPE
 - Water Liquid
 - Coordinate Systems
 - Global Coordinate System
 - Connections
 - Contacts
 - Contact Region
 - Mesh
 - Named Selections
 - Waterdomain
 - Transient Thermal (A5)
 - Initial Temperature
 - Analysis Settings
 - Convection
 - Convection 2
 - Commands (APDL)
 - Solution (A6)
 - Solution Information
 - Temperature - Global Maximum
 - Temperature - Global Minimum
 - Temperature

Section Planes

- Section Plane1
- Section Plane2

Details Section Planes



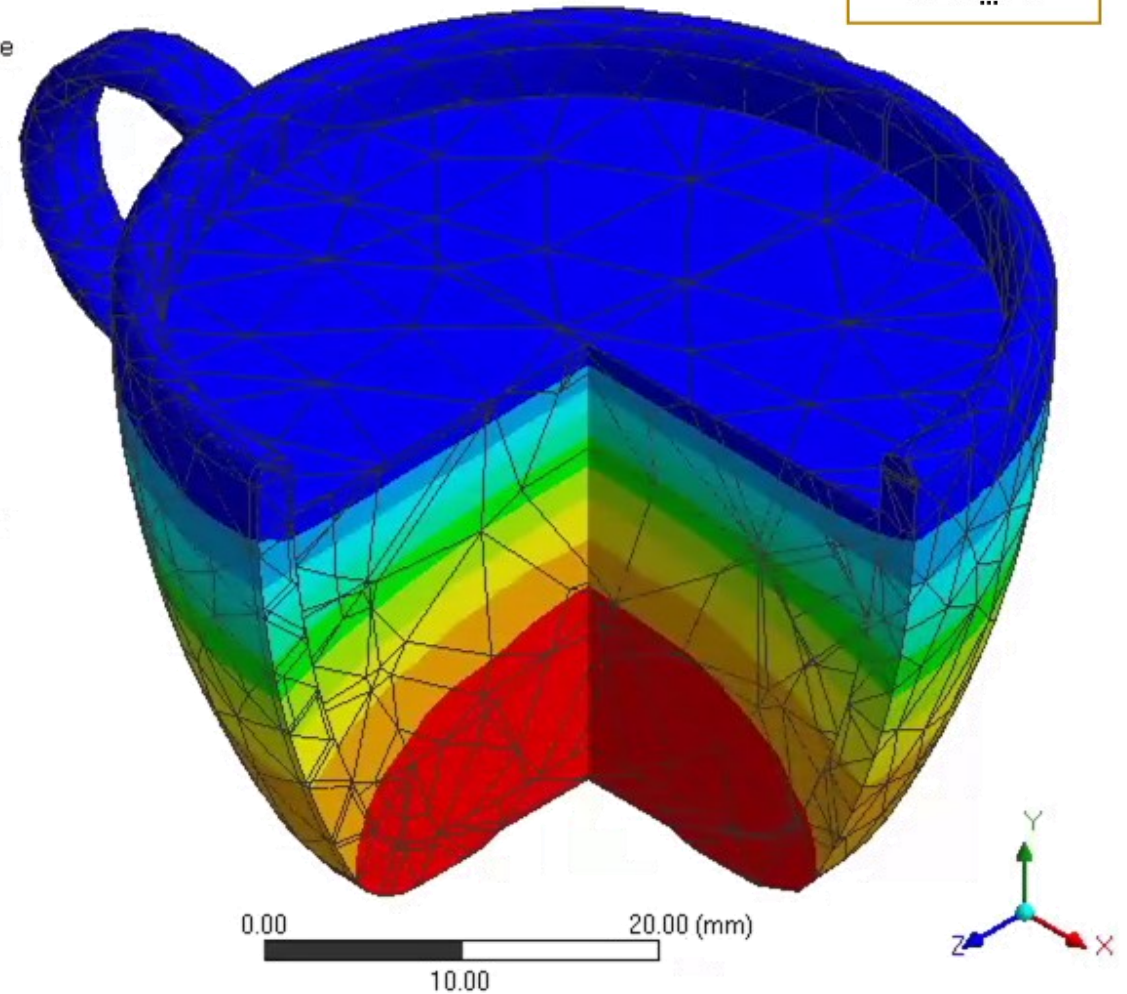
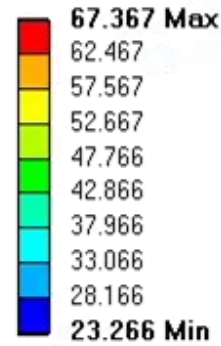
Post processing



SLING

A: Transient Thermal

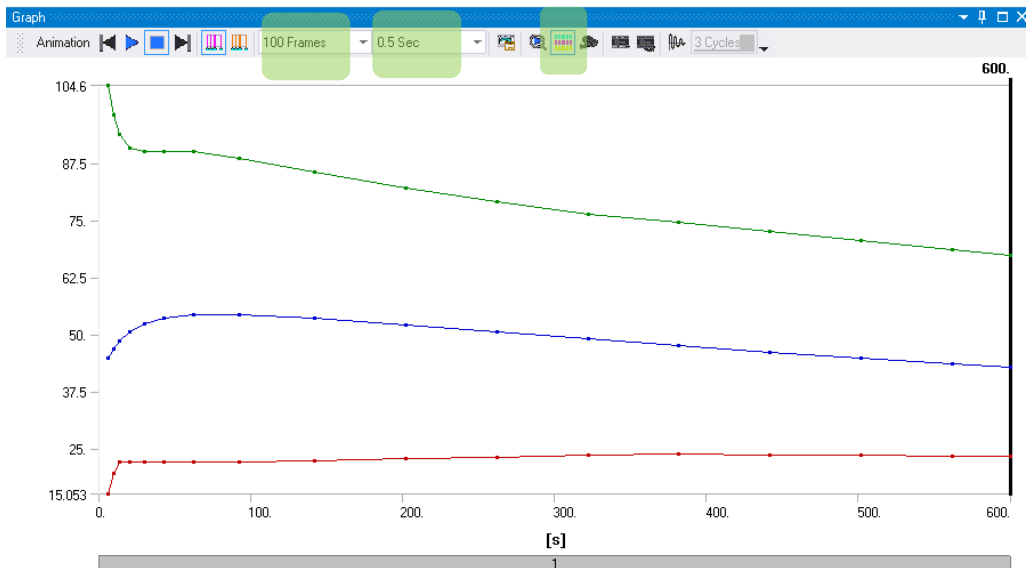
Temperature
Type: Temperature
Unit: °C
Time: 600
2/10/22 11:55 AM



Details of "Model (A4)"

| Lighting | |
|----------|-----|
| Ambient | 0.3 |
| Diffuse | 0.6 |
| Specular | 1 |
| Color | |

| Filter Options | |
|----------------|---------|
| Control | Enabled |



Changing the mesh element size

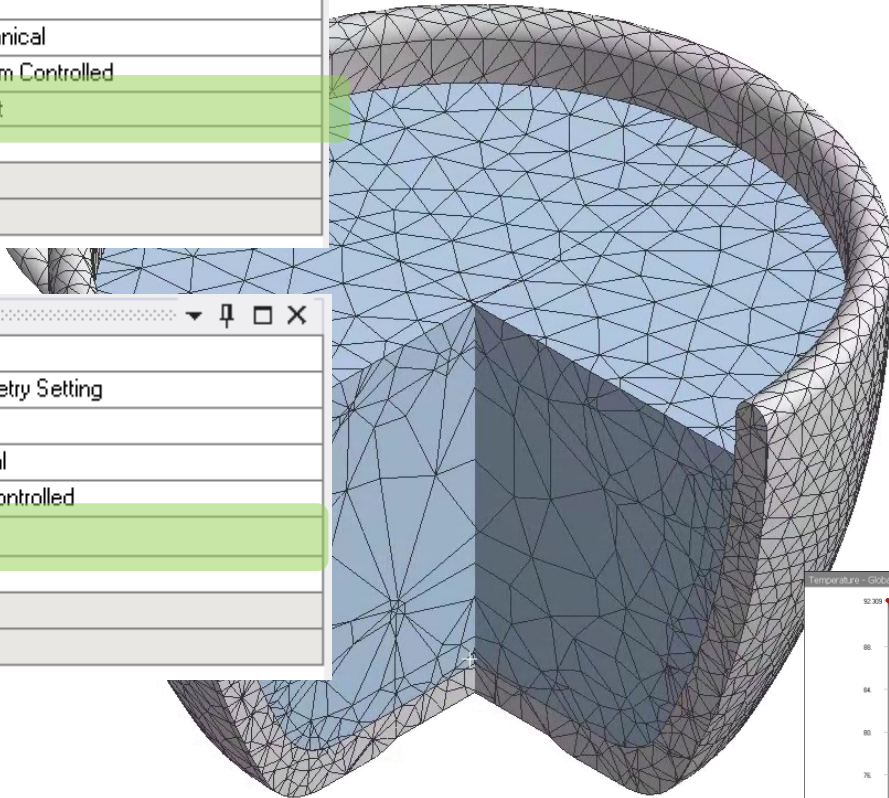


SLING

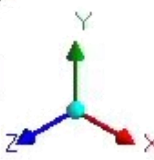
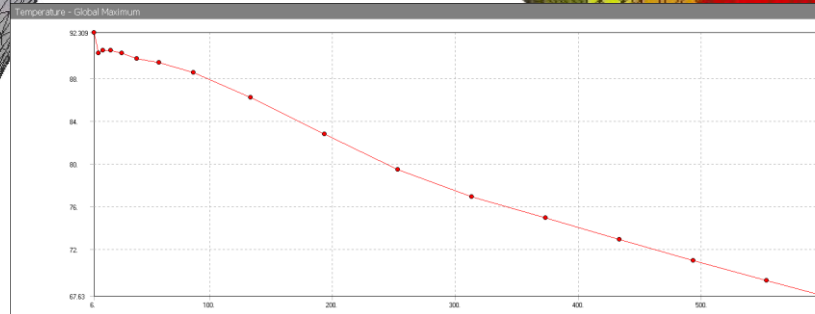
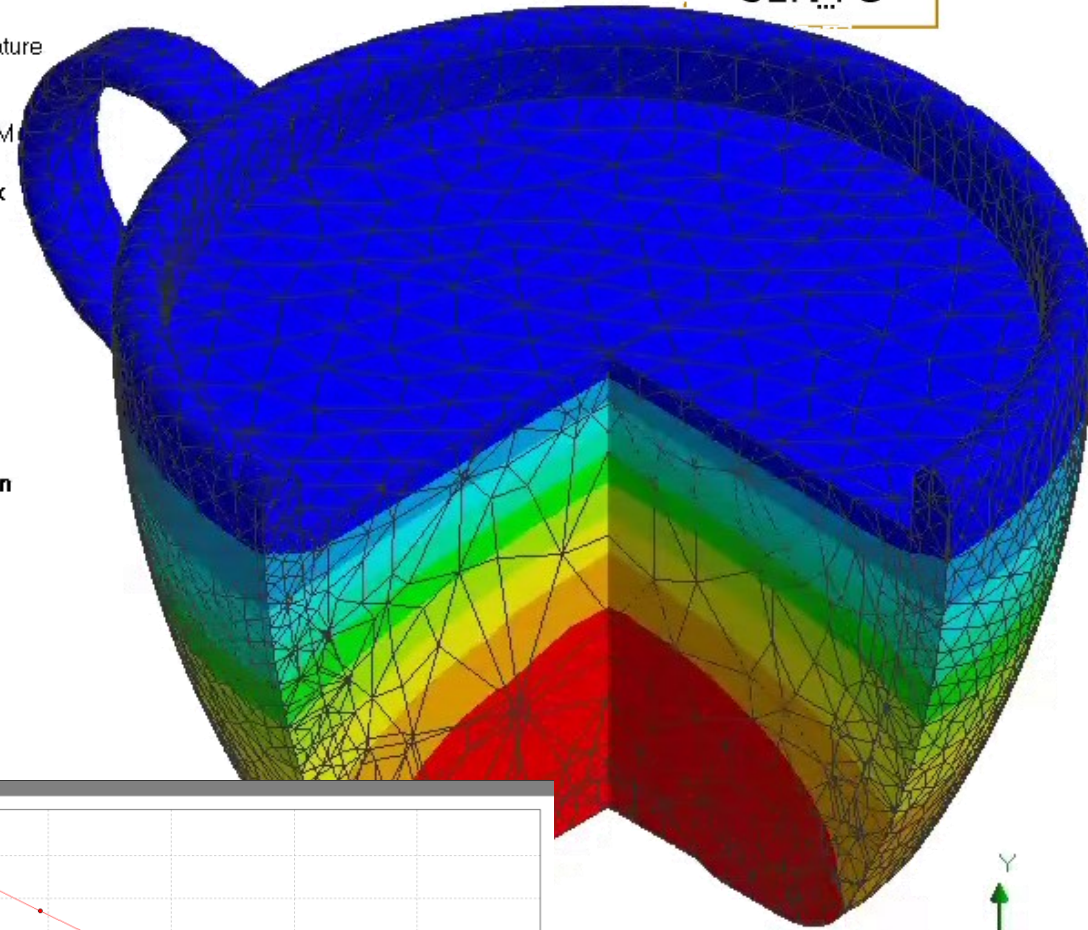
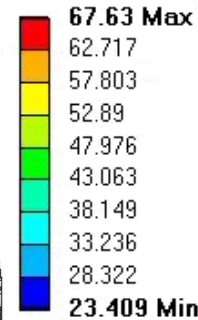
Element size: 1,5mm

| Details of "Mesh" | |
|---------------------------------------|----------------------|
| Display | |
| Display Style | Use Geometry Setting |
| Defaults | |
| Physics Preference | Mechanical |
| Element Order | Program Controlled |
| <input type="checkbox"/> Element Size | Default |
| Statistics | |
| <input type="checkbox"/> Nodes | 7336 |
| <input type="checkbox"/> Elements | 3703 |

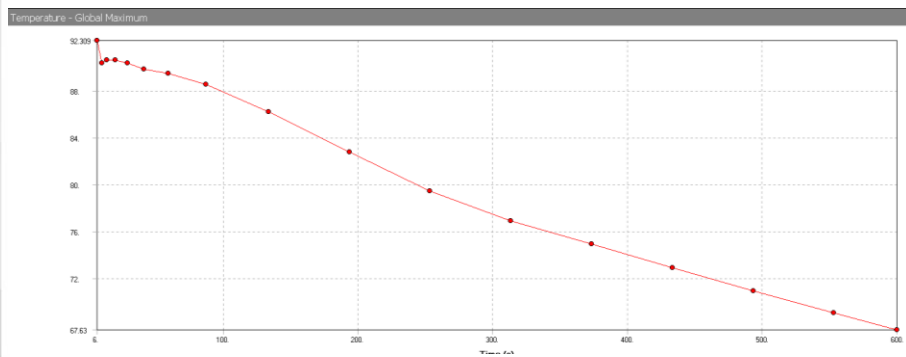
| Details of "Mesh" | |
|---------------------------------------|----------------------|
| Display | |
| Display Style | Use Geometry Setting |
| Defaults | |
| Physics Preference | Mechanical |
| Element Order | Program Controlled |
| <input type="checkbox"/> Element Size | 1.5 mm |
| Statistics | |
| <input type="checkbox"/> Nodes | 47526 |
| <input type="checkbox"/> Elements | 26640 |



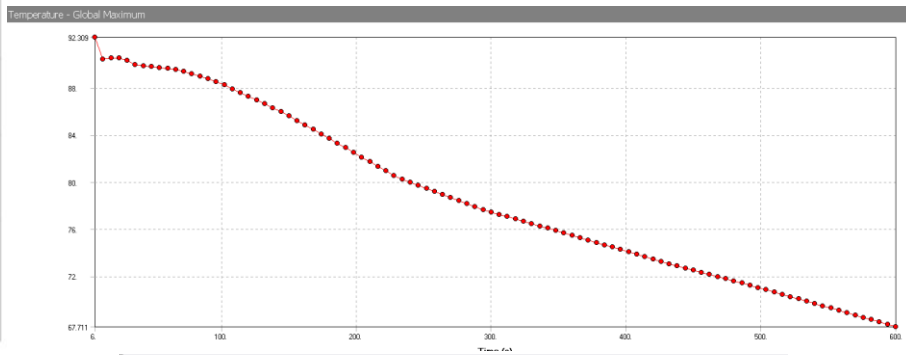
A: Transient Thermal
Temperature
Type: Temperature
Unit: °C
Time: 600
2/10/22 12:12 PM



Changing the time step

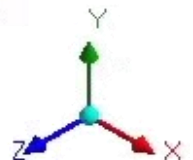
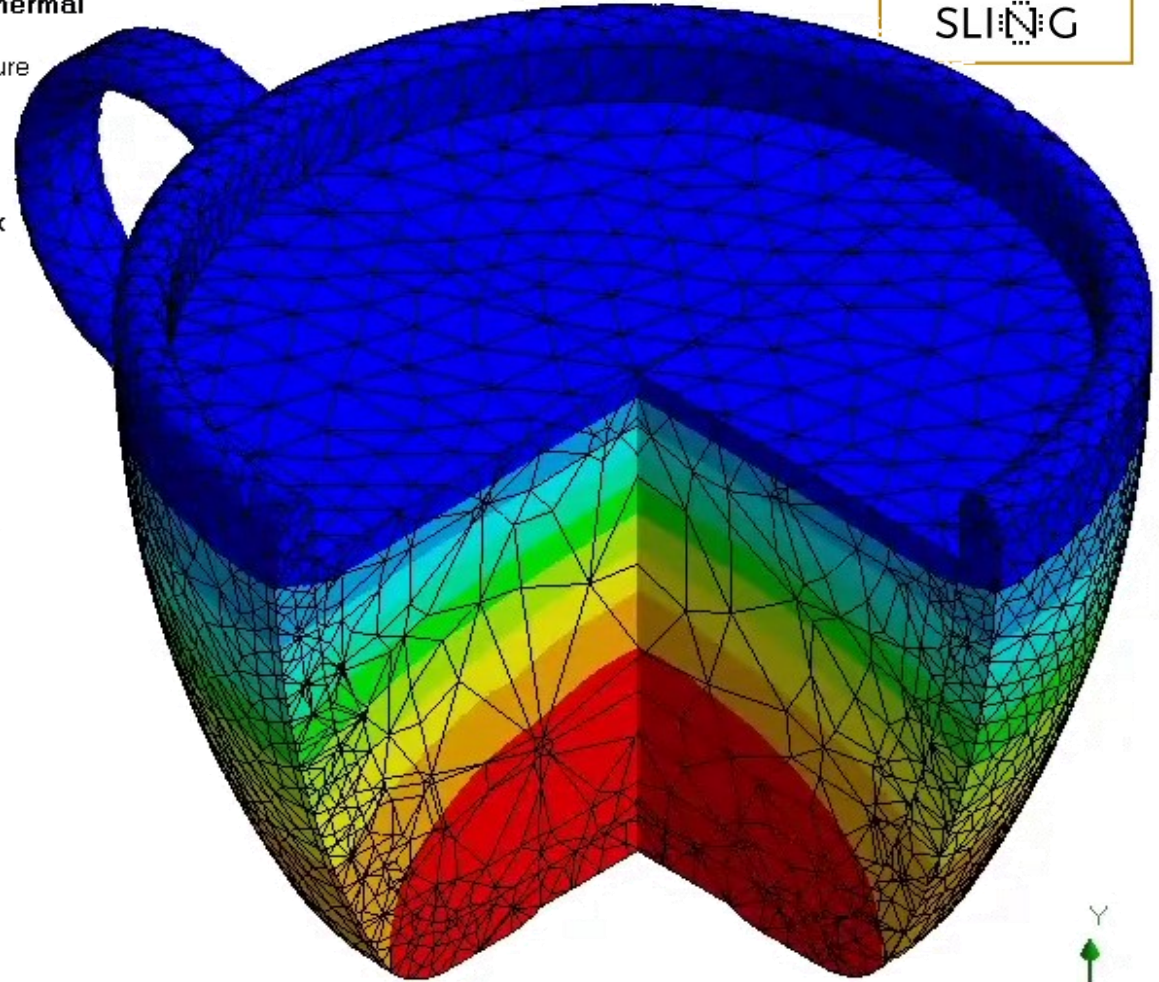
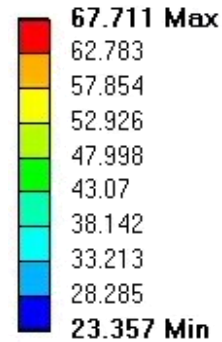


Timestep: 6 sec



A: Transient Thermal

Temperature
Type: Temperature
Unit: °C
Time: 600
2/10/22 1:24 PM

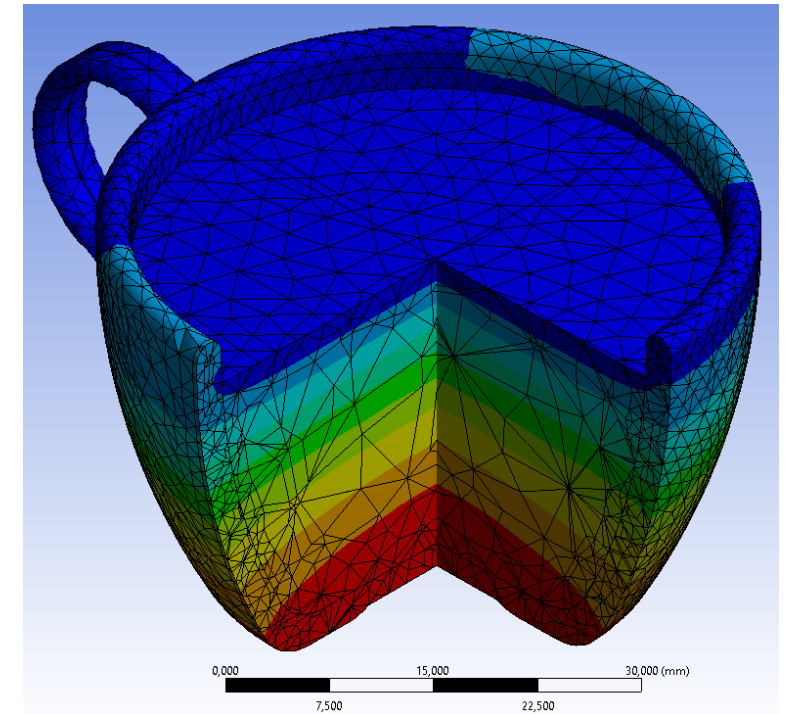
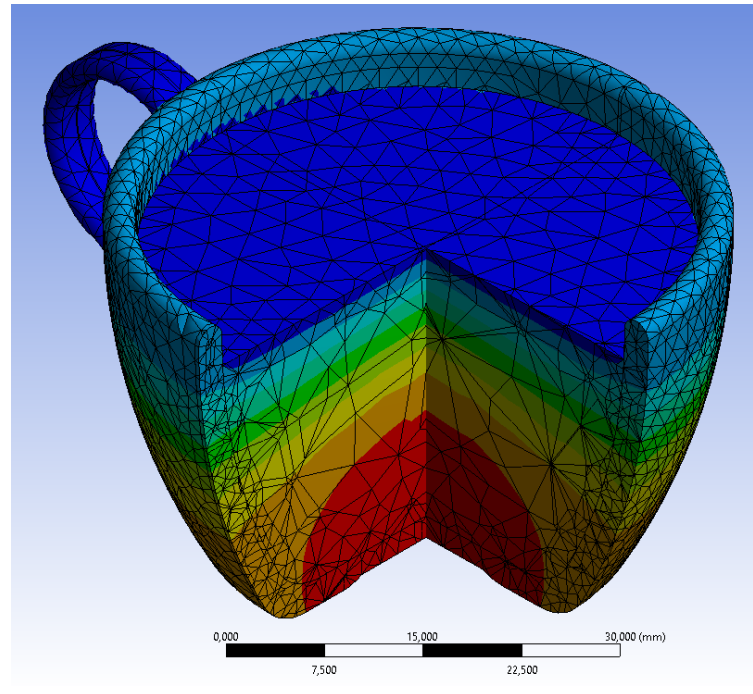
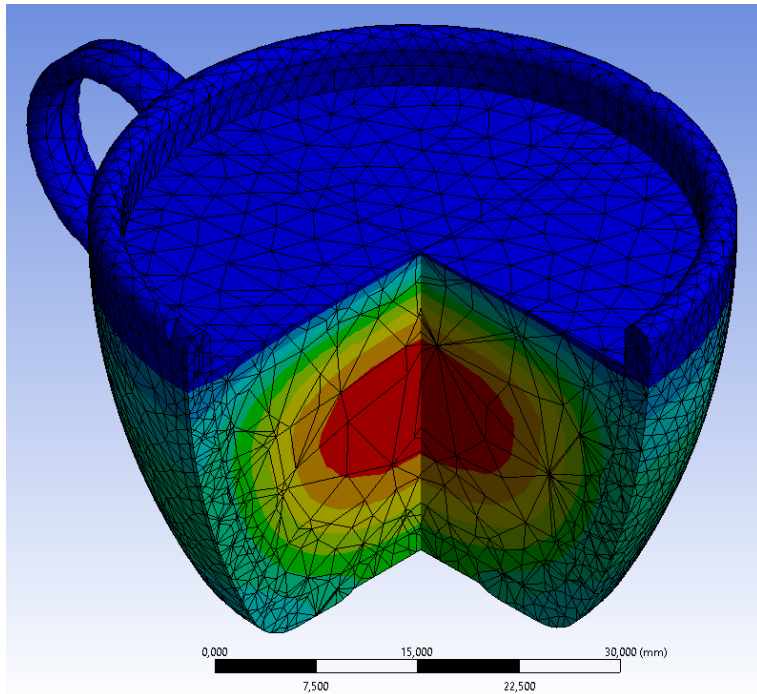


| Details of "Analysis Settings" | |
|--------------------------------|-------------|
| Step Controls | |
| Number Of Steps | 1. |
| Current Step Number | 1. |
| Step End Time | 600. s |
| Auto Time Stepping | Off |
| Define By | Time |
| Time Step | 6. s |
| Time Integration | On |
| Solver Controls | |

Your changes



- Better mesh?
- Timestep?





Thanks!



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EuroHPC
Joint Undertaking