Contents

Exercise 4.1: Thermal Gradient & Pressure on a Spherical Tank

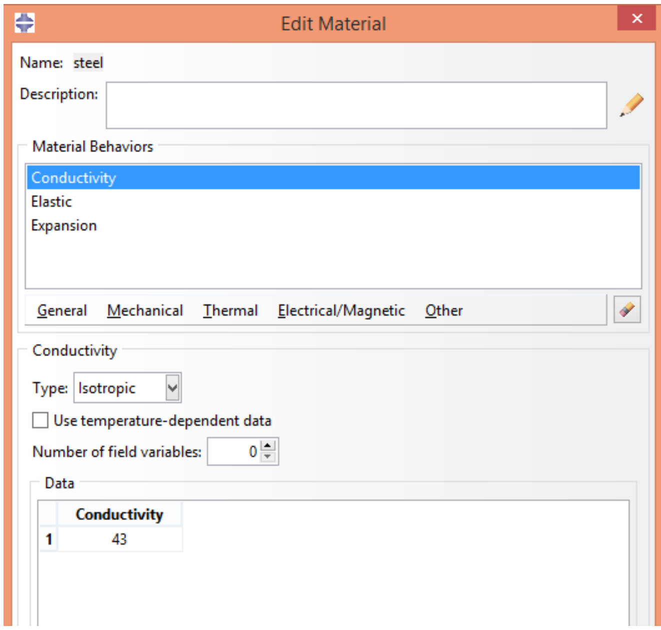
We will now calculate factors involved with a spherical steel tank under the effect of both a thermal gradient and pressure due to a contained fluid.

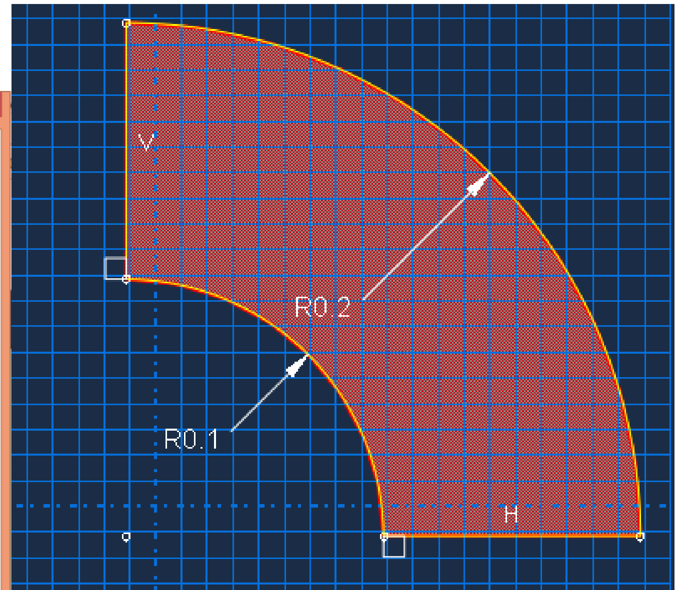
Data files are available.

Modeling

1. Create a `2D deformable Shell` part, named `Tank`. The approximate size should be `0.5`.

   Use the *Create Arc*  and *Connected line*  tools to create a quarter of Spherical Tank. Use *Add Dimension*  to set the inner radius to be 1.E-1; outer radius to be 2.E-1.





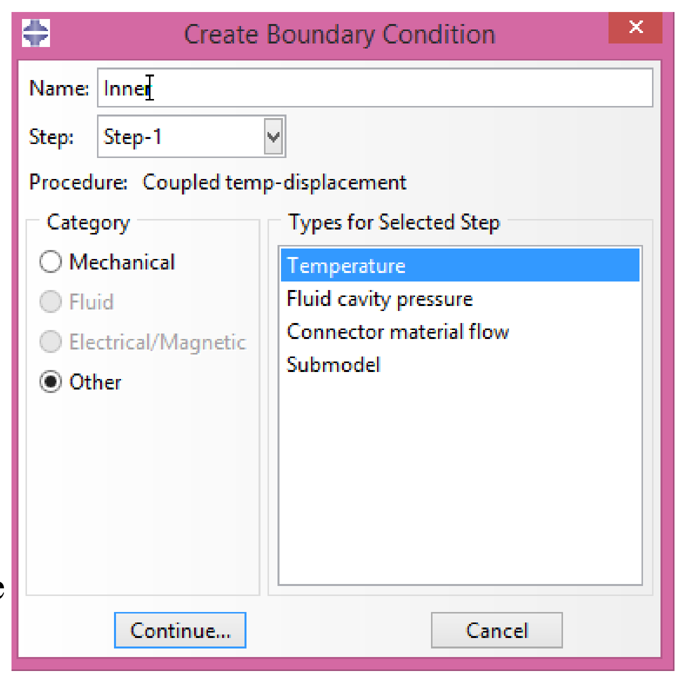
2. Create a material named `Steel`.
    1. Define the `Elastic property` with $E = 210.E9$ and $\nu = 0.3$.
    2. We need to define more properties for the coupled problem. Open the *Edit Material* dialog box.
        1. In `Mechanical→Expansion`, define thermal expansion coefficient to be `1.2E-5`.
        2. In `Thermal→Conductivity`, define the thermal conductivity to be `43`.
3. Create the section of this material named `SteelSection` and assign it to the `Tank` part.

Predefined Conditions

1. First instance the `Tank` part and create a new step named `CouTemp` of type is `General Coupled temp-displacement`.
    1. In the *Edit Step* dialog box, choose `Response type` `Steady-state` and toggle on `Nlgeom`.

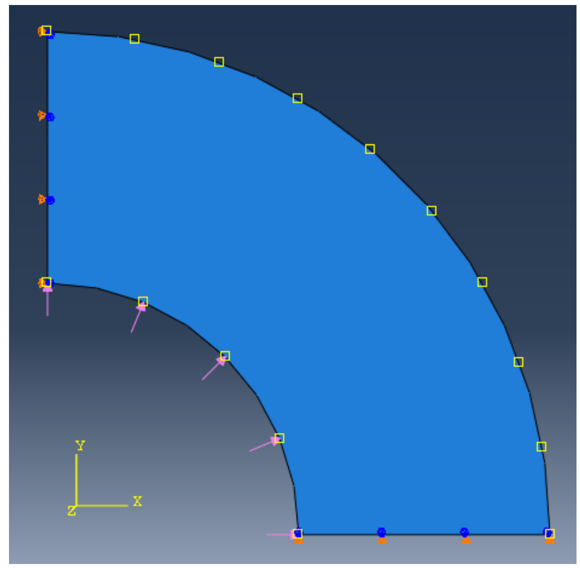
2. Since it is a quarter of the tank, we define symmetry boundary condition at the left and bottom. From `Initial Step`, at the left boundary fix `U1` and `UR3`; at the bottom boundary fix `U2` and `UR3`.

3. In the step `CouTemp`, we create a temperature boundary along the inner surface of tank. Choose *Create Boundary Condition*.

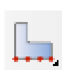


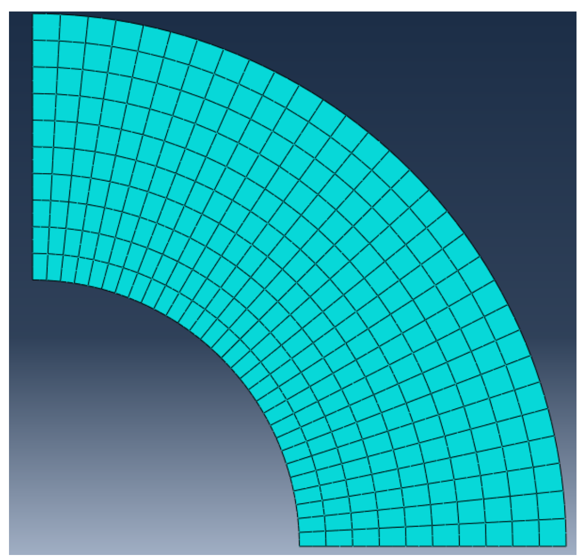
1. In this dialog box, select *Category* `Other` and *Types* `Temperature`, naming it `InnerTemp` with *Magnitude* `100`.
2. Similarly, define an outer surface temperature of `30`.

4. The contained fluid also exerts pressure on the inner surface of the tank. Define an `InnerPressure` of `30E5` along the inner surface.



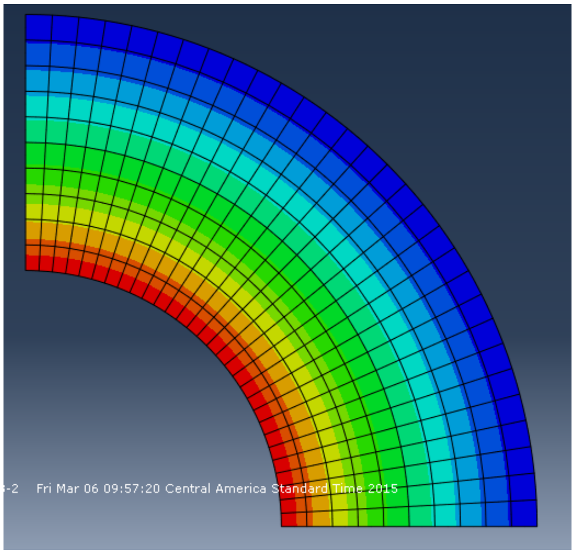
Meshing

1. Use the *Seed edges*  tool to seed the inner and outer edge with `30` elements.
2. Seed the left and bottom edge with `10` elements.
3. For the elements, choose the `Standard` element library in the `Coupled Temperature-Displacement` family with a `Quadratic` order `Reduced integration (CPE8RT)` method. Use `Quad/Structured` to mesh the part.



Job & Postprocessing

1. Create a job, save it, and run it.
2. Observe the resulting temperature distribution and stress distribution with *Field Output*.



Reference

This tutorial is based on an example by Lam Phung.

Credits

Neal Davis, Ruizhi Li, Binyue Hou, and Masoud Safdari developed these materials for Computational Science and Engineering at the University of Illinois at Urbana–Champaign.