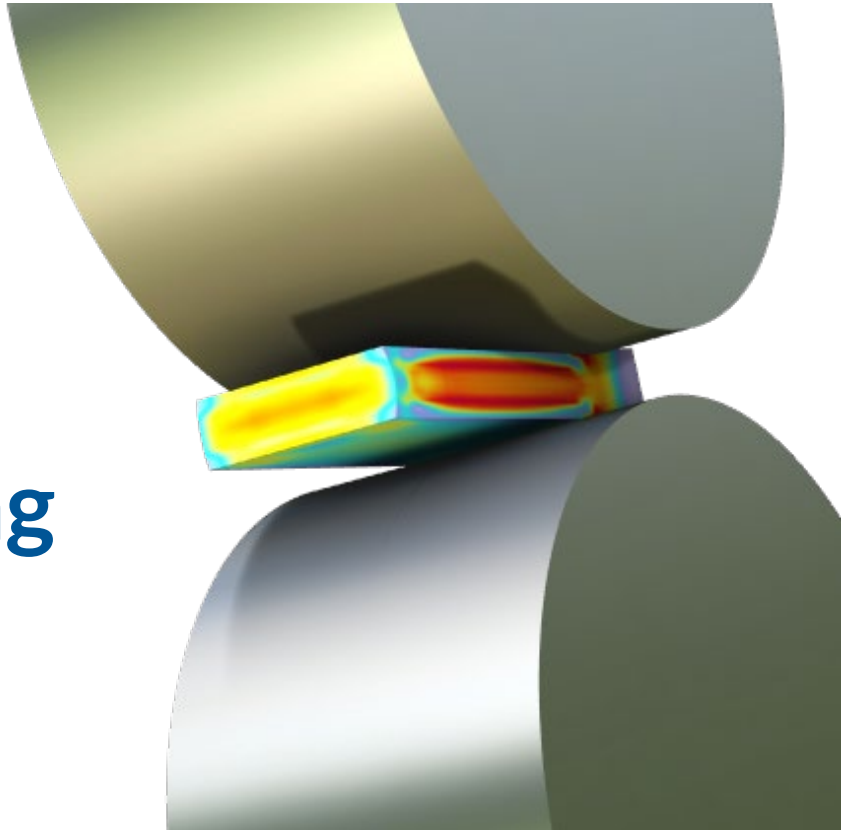
COMSOL

COMSOL Multiphysics®

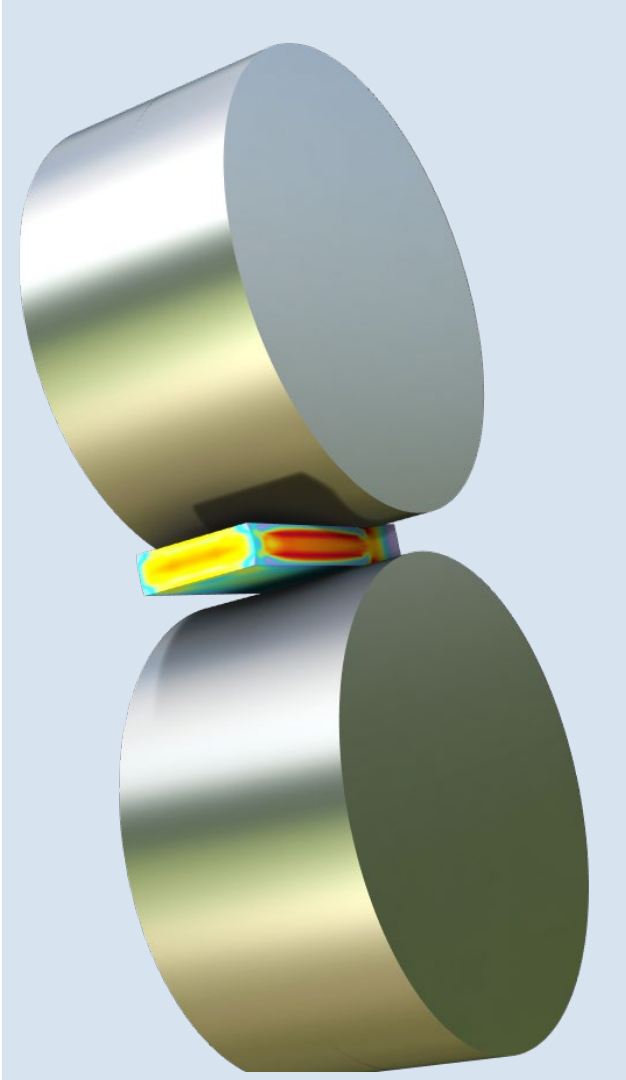
Model of Roll Forming

COMSOL



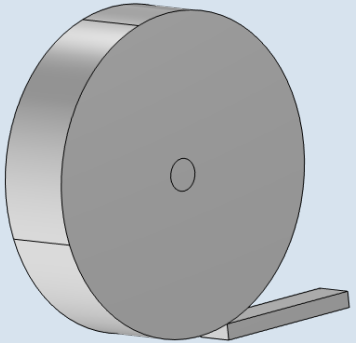
Background

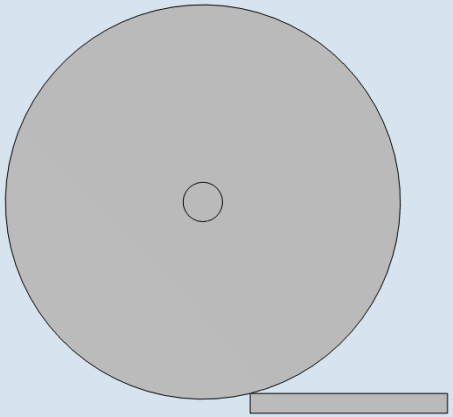
- This model demonstrate the process of cold rolling, where a workpiece is pressed through a pair of rollers at room temperature
  - Related applications: metal forming, rolling of battery electrodes, …
- Assumptions and simplifications:
  - Ignores the deformation of the rollers (rigid bodies)
  - The workpiece is free, without pretension
- From this model, it is possible to:
  - Understand how to simulate roll forming processes
  - Obtain detailed results of residual stress and final deformation



Geometry

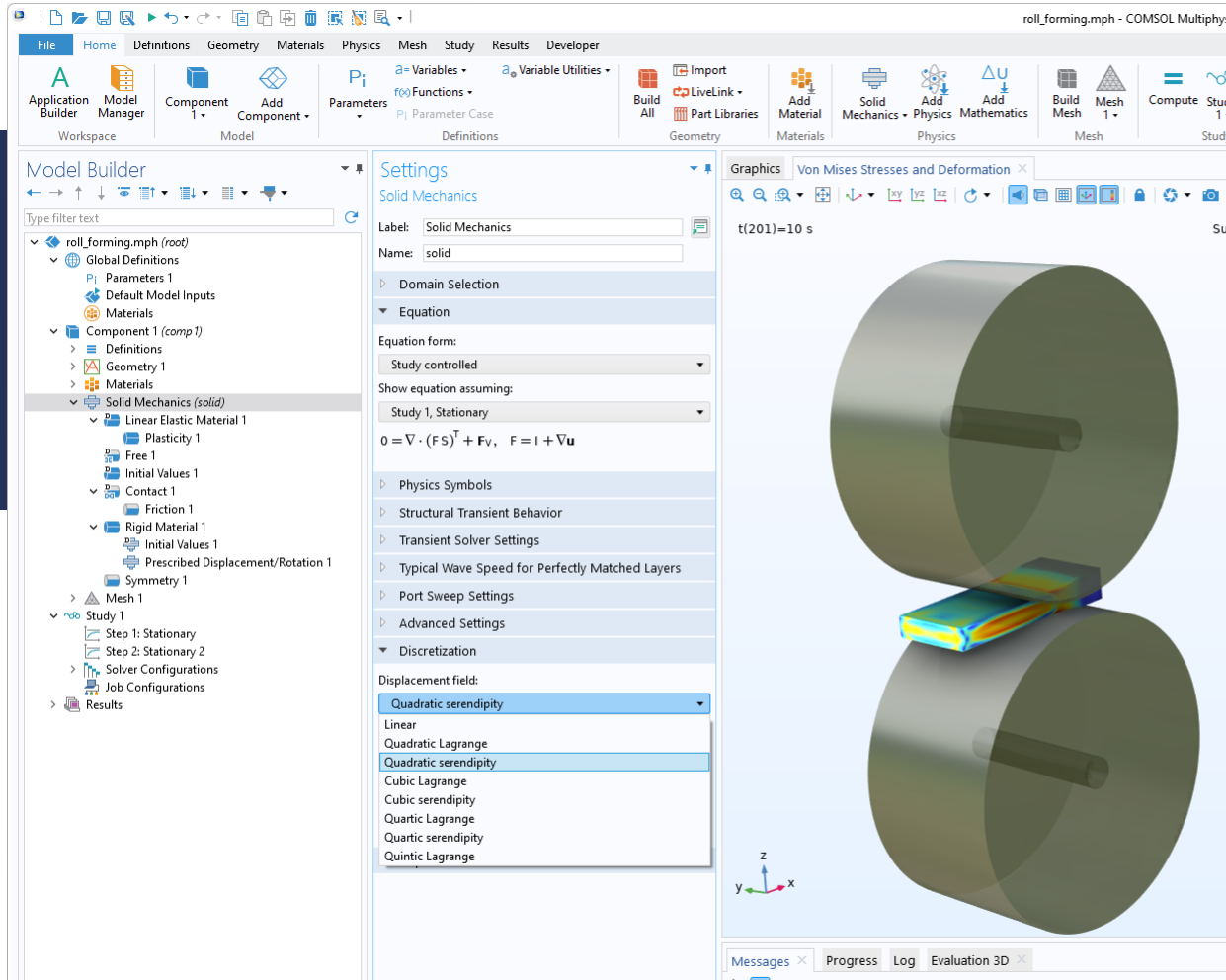
- Due to symmetry, only ¼ of the geometry needs to be modeled
- Parameterized geometry with respect to:
  - Radius and width of the roller
  - Length, width, and thickness of the workpiece
  - Ratio of the roller gap to the thickness of the workpiece





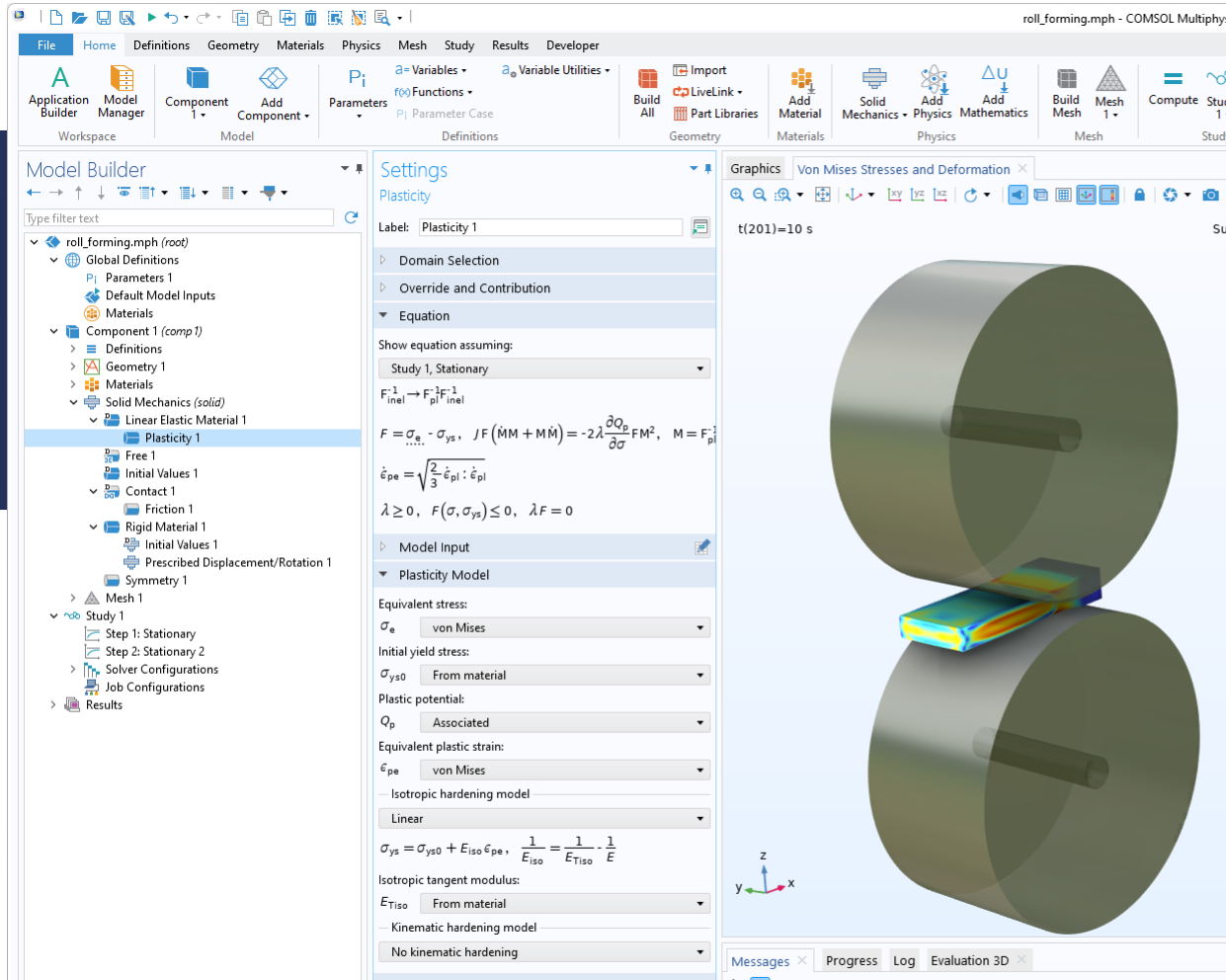
Discretization

Quadratic serendipity elements are used (default). These elements give decent accuracy at a relatively low computational cost (solution time and memory).



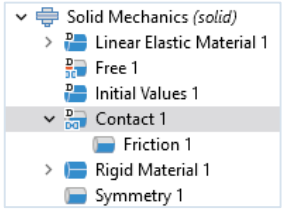
Material Model

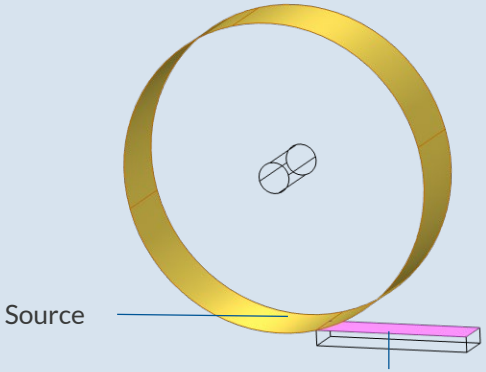
- *Rigid Material* for the roller
- *Plasticity* to describe the permanent deformation of the workpiece during rolling
  - A *Linear* isotropic hardening model is used

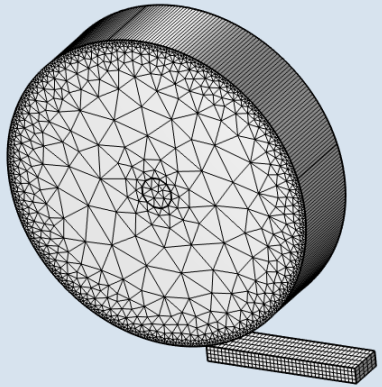


Contact Modeling

- A *Contact* feature is added to describe the contact between the rollers and the workpiece:
  - Cause deformation and movement of workpiece
  - Calculate contact pressure and friction
- Contact pairs setting
  - Set the surface of workpiece as *destination boundary*
  - Use the *Penalty* method
    - Set a relatively large penalty factor to avoid the penetration of highly compressed surfaces
  - Add a *Friction* feature
    - Set friction coefficient as 0.3
- Refine the meshes at the contact surfaces

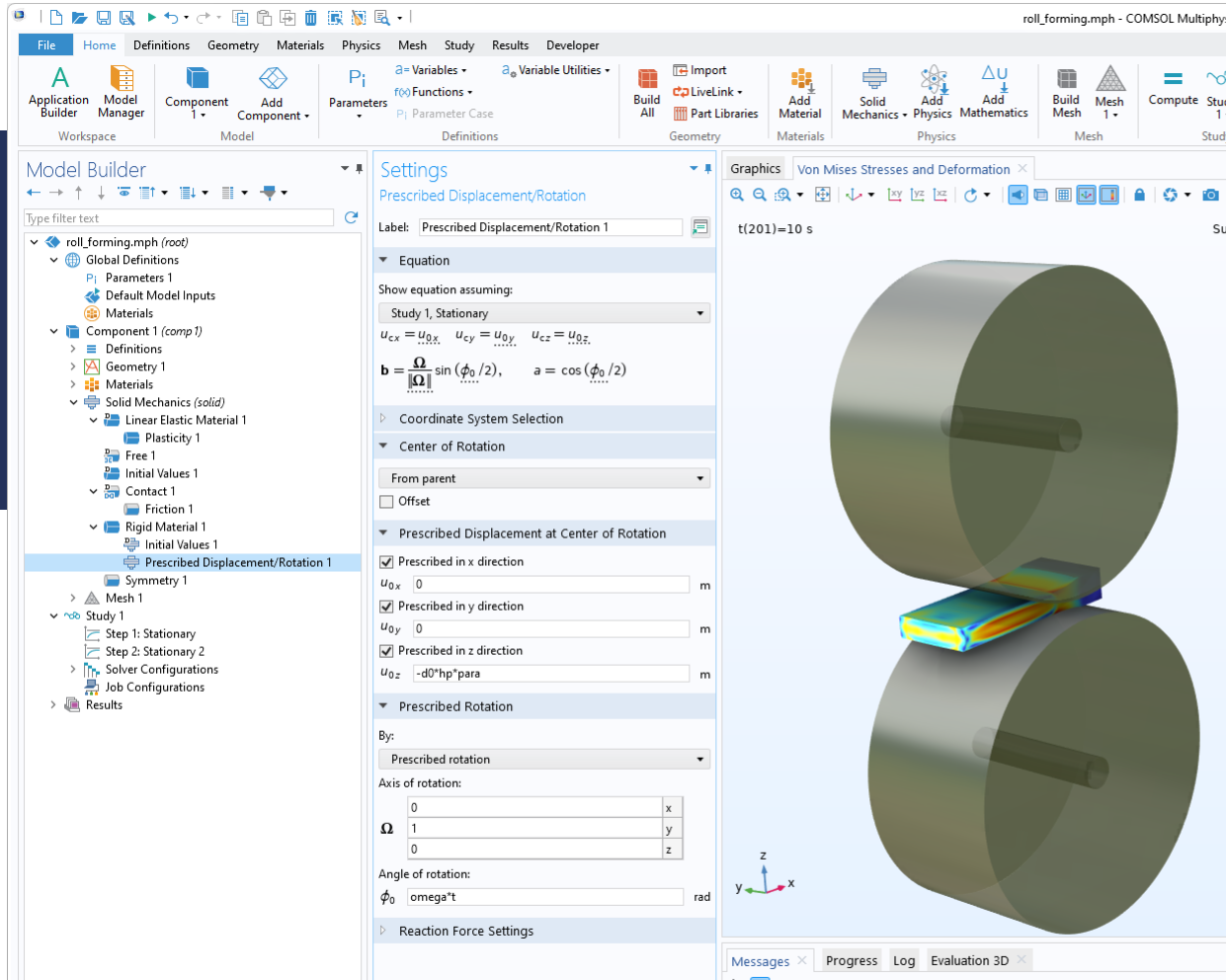






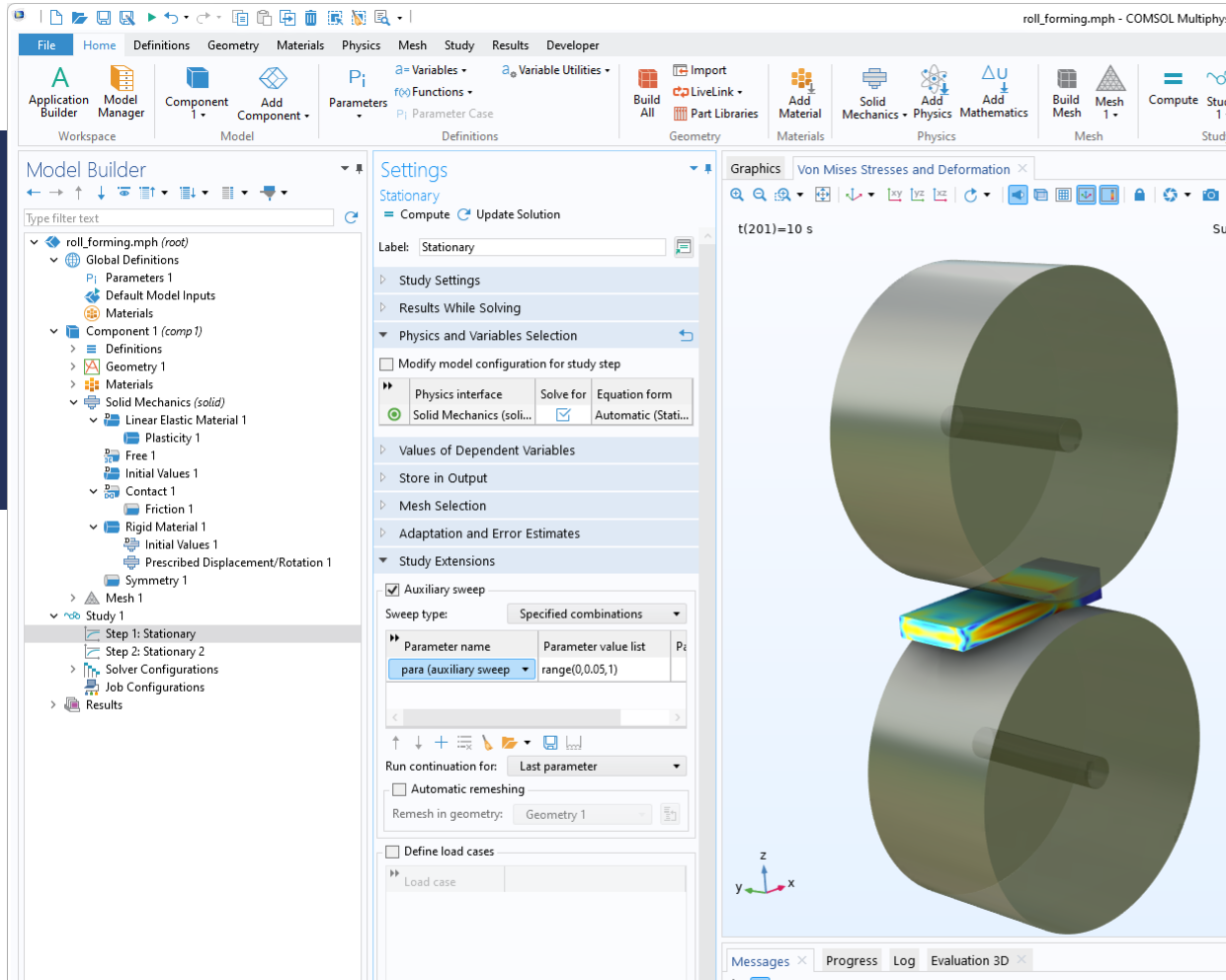
Prescribed Displacement and Rotation

- *Prescribed Displacement at Center of Rotation*: moves the rigid roller down slightly to activate the surface contact through the parameter "`para`".
- *Prescribed Rotation*: rotates the roller by changing the *Angle of rotation* in order to press and to pull the workpiece forward by friction through the parameter "`t`".



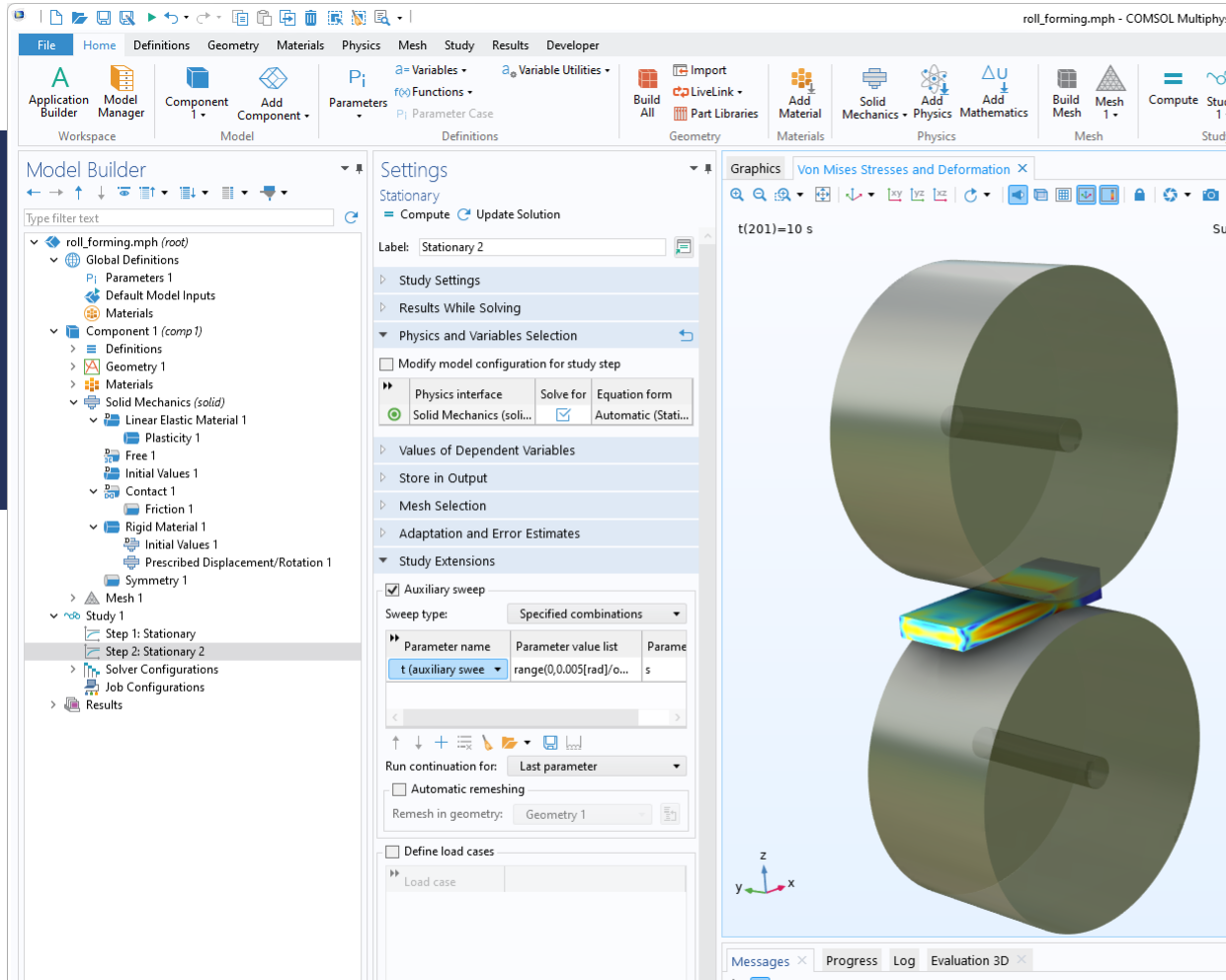
Study Settings

Auxiliary sweeps are selected to vary the parameters that control the initial contact (`para`) and the rotation of the roller (`t`).



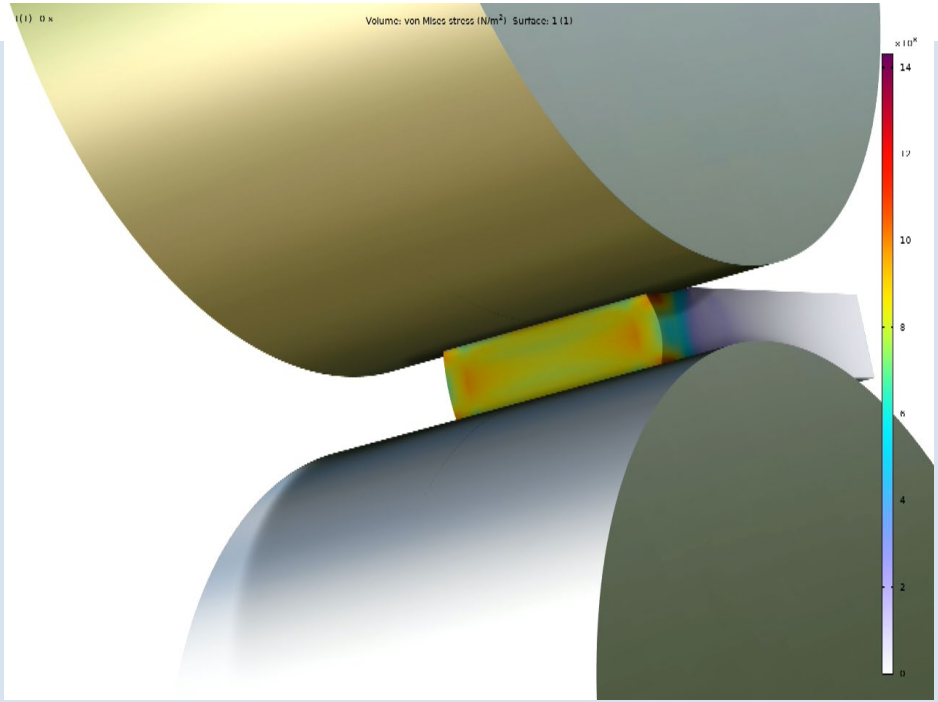
Study Settings

Auxiliary sweeps are selected to vary the parameters that control the initial contact (`para`) and the rotation of the roller (`t`).



Results

Rolling process, deformation and von Mises stress.



Summary

- Important modeling features:
  - Contact modeling for compression and friction between roller and workpiece
  - Plasticity with isotropic hardening
  - Auxiliary sweep for process simulation
- Possible extensions:
  - Consider the deformation of the rollers
  - Adding additional forces to the roller
  - Changing the material constitutive model, *e.g.*, use viscoelasticity
  - Include thermal effects

