SMA Spring Simulation in COMSOL Multiphysics

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1. Objective

To design and simulate a Nitinol (Ni-Ti) Helical Spring in COMSOL Multiphysics.

2. Equipment Required

PC with COMSOL Multiphysics installed.

3. Procedure

3.1 Initial Setup

1. Launch *COMSOL Multiphysics* software and select *Model Wizard.*
2. **Select *Space Dimension*:** *3D*
3. **Select *Physics*:** *Structural Mechanics → Joule Heating and Thermal Expansion*
4. **Select Study:** *Stationary*
5. **Define *Units*:** *mm*

3.2 Create Spring Geometry

1. Right-click *Geometry → More primitives → Helix*
2. Set the *Dimensions* as required

3.3 Add Material

1. Under the *Add Material* tab, browse to *Material Library → Nickel Alloys → Ni-Ti (shape memory)* and click *Add to Selection.* Then select the *Spring* geometry.
2. Define the *Material Properties* by entering appropriate values in the table.

3.4 Apply Boundary Conditions

1. *Solid Mechanics → Fixed Constraint* on one of the spring faces
2. *Heat Transfer in Solids → Temperature* (293 K) on the fixed spring face
3. *Electric Currents → Ground* on the fixed spring face
4. *Electric Currents → Terminal* (0.5 A) on the free spring face

3.5 Mesh

1. Define *Mesh Element Size*. Note that finer mesh gives more accurate results but requires more computation time.
2. Click *Build All* to apply the mesh.

3.6 Compute the Study

1. Click on *Compute* button to compute the study.

3.7 Define Custom Results

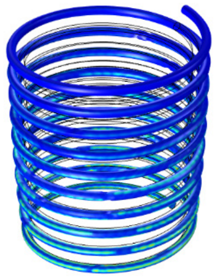
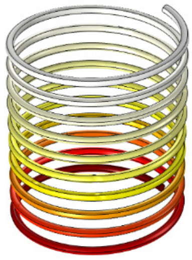
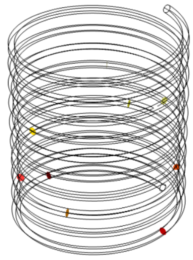
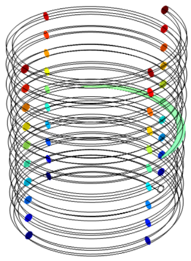
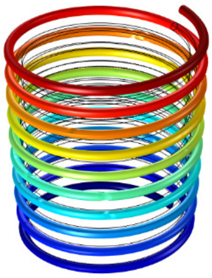
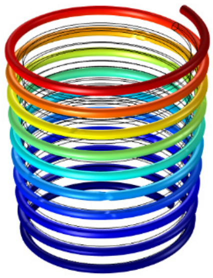
1. Right-click on *Results* and select *3D Plot Group.* Rename the study as required.
2. Right-click on the newly created *3D Plot Group* and select *Surface.*
3. Dropdown the *Expressions* tab and select the required analysis (e.g. Solid Mechanics → Displacement → Total Displacement).

3.8 Visualize the Results

1. Visualize the results by clicking on the respective *3D Plot Groups.*
2. The results can be saved to a file by clicking on *3D Image* button in top pane.

For a detailed video tutorial, please visit https://youtu.be/XYLJCq5xsXU.

4. Results

		
von Mises Stress	Temperature Gradient	Isothermal Contours
		
Electric Potential	Total Displacement	Vertical Displacement

The maximum total displacement when 0.5 A current was flown through the SMA Spring was 80 mm.

The maximum vertical displacement when 0.5 A current was flown through the SMA Spring was 70 mm.

Appendix: Nitinol Properties

Property	**Variable**	**Value**	**Unit**
Density	ρ	rho(T[1/K])	Kg/m^3
Thermal Conductivity	k	18	W/m.K
Heat Capacity at Constant Pressure	c_p	837.36	J/kg.K
Electrical Conductivity	σ	12195	S/m
Relative Permittivity	ϵ	1	1
Coefficient of Thermal Expansion	α	11E-6	1/K
Young’s Modulus	E	E(T[1/K])	Pa
Poisson’s Ratio	μ	0.33	1