Mechanical and Thermal Loading of a Composite Gun Barrel

Kyle Koppenhoefer, Jeffrey Crompton and Sergei Yushanov
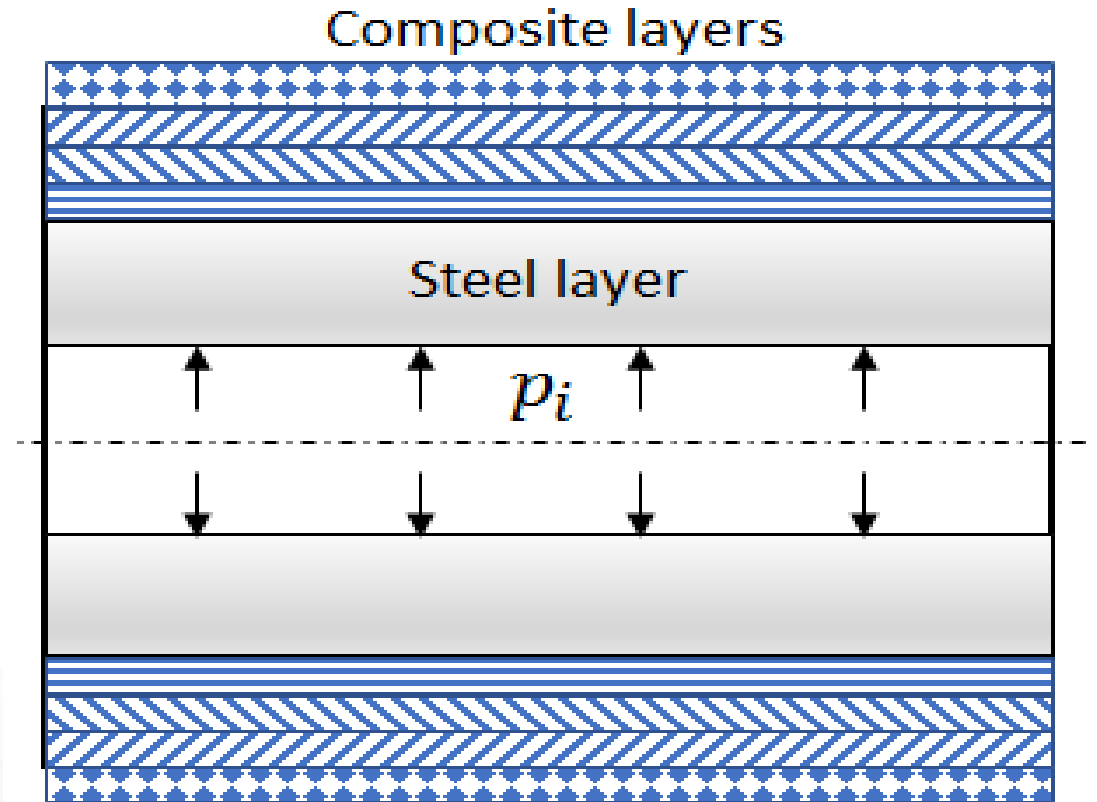
Motivation

- Reduced weight of gun barrel
- Improved thermal response of gun barrel

Method to analyze barrel designs

- Method to determine ply orientation and lay-up orientation of the composite layers on the interlaminar stresses and stress distribution along the barrel.

Composite layers

Steel layer

p_i

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COMSOL Multiphysics Model

- Multiple materials on same boundary for composite

- Global material in COMSOL

- Layered material option references global material and defines lay-up angles and layers thicknesses

- Laminate thermo-mechanical properties also defined

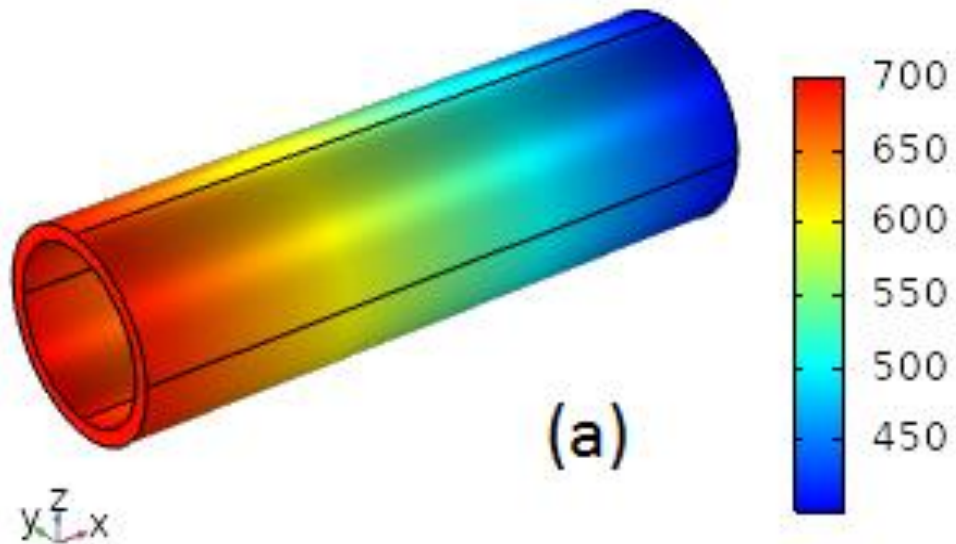Layered Shell - Composite
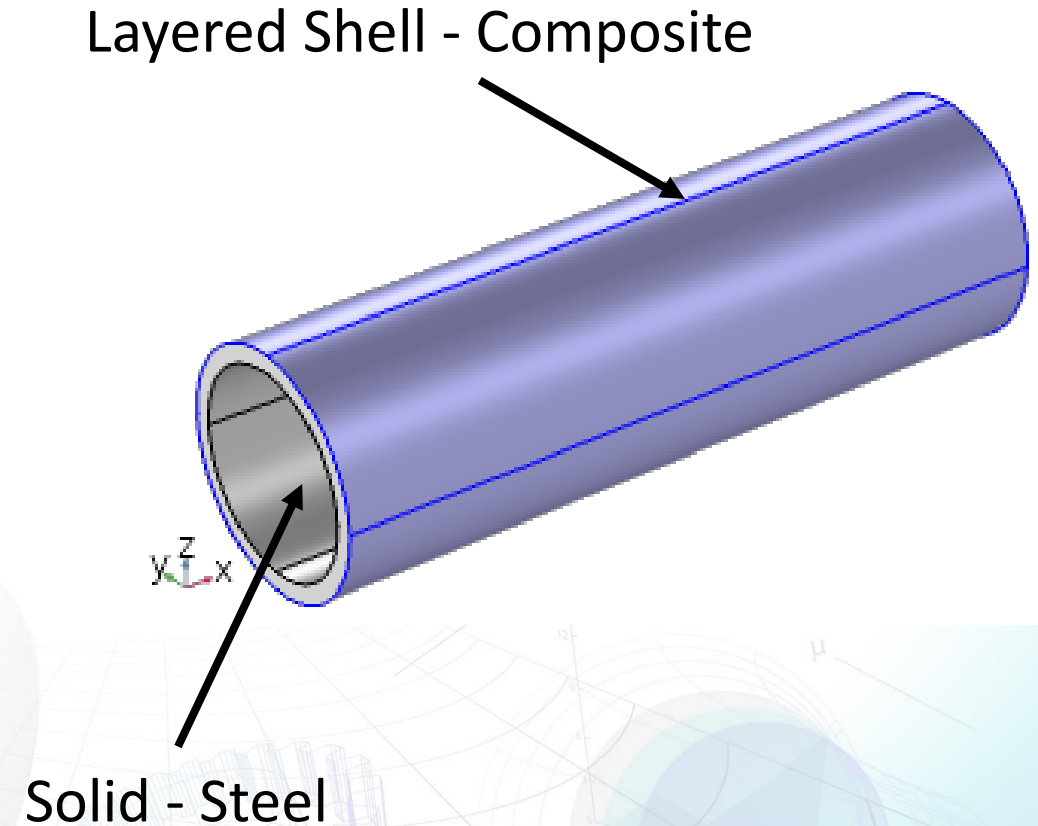
Solid - Steel

Physics Interfaces

- Solid Mechanics – steel
- Layered Shell – composites
- Heat Transfer in solids – steel
- Heat Transfer in shells – composite
- Multiphysics
  - Thermal expansion – couples structural and thermal analysis
  - Thermal expansion, shells – couples structural and thermal for composites

▷ 🟦 Solid Mechanics *(solid)*
▷ 🗂 Layered Shell *(lshell)*
▷ 📙 Heat Transfer in Solids *(ht)*
▷ 📄 Heat Transfer in Shells *(htlsh)*
◢ 🔧 Multiphysics
　　🟧 Thermal Expansion 1 *(te1)*
　　🟧 Thermal Expansion, Layered Shell 1 *(tel1)*

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Temperature Distribution – Steel and Composite

Steel
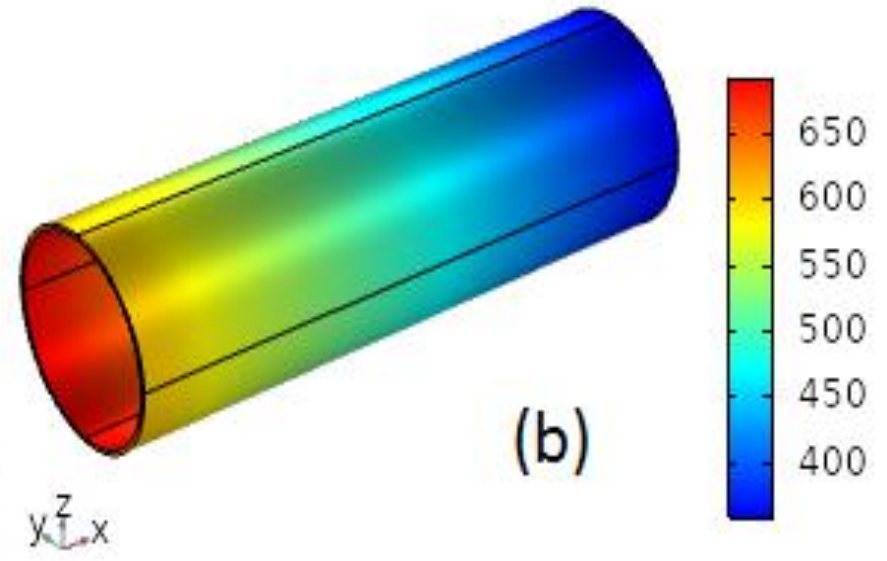
Composite

Stress in Composite
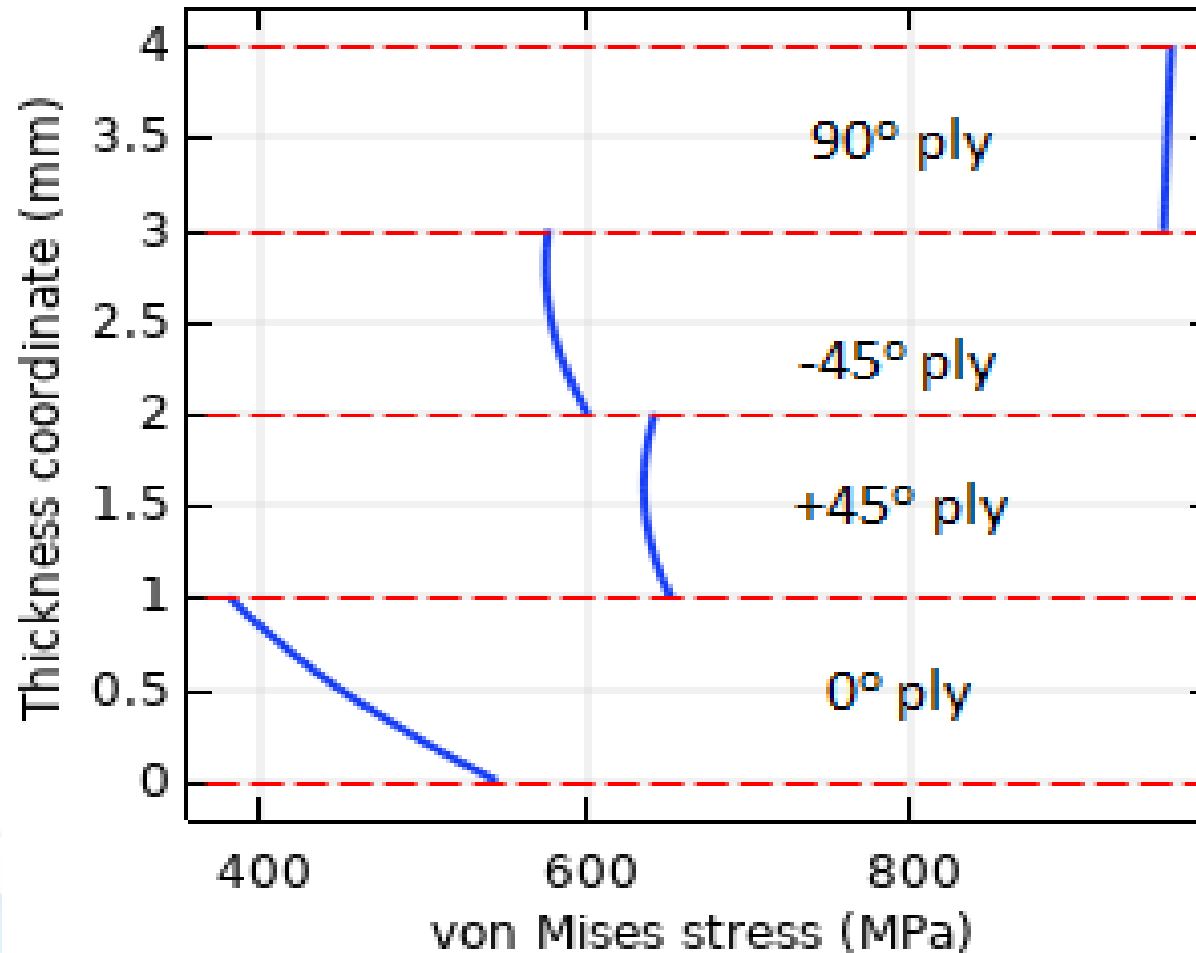
Tsai-Wu Failure Criterion
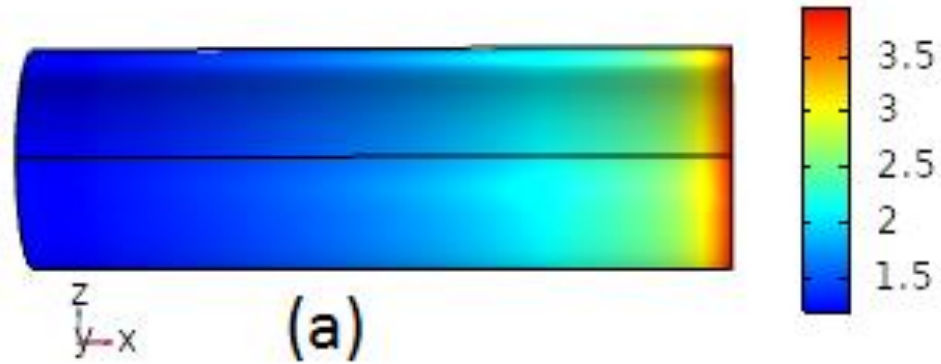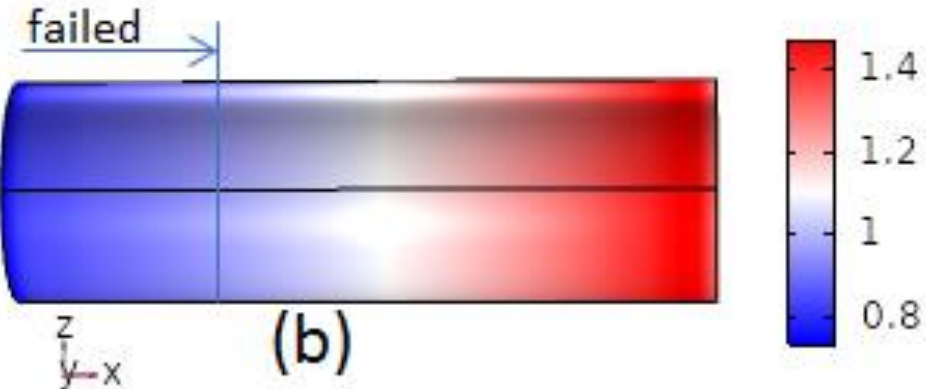
Value < 1 indicates failure

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Conclusion

- Simulation of composite gun barrel developed
- Mechanical loading due to internal pressure
- Thermal loading due to temperature gradient
- Tsai-Wu failure criterion applied
- Failure predicate in ply near breech end