Development of Novel Thermoplastic Orthotic Springs Made From Repurposed Materials

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MAMS Multiscale Analysis of Materials & Structures

JCAT THE JOINT CENTER FOR AEROSPACE TECHNOLOGY INNOVATION

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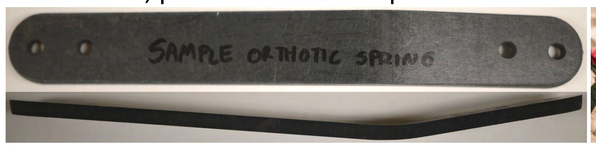
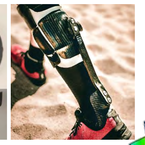
Background

- Recycled fiber reinforced thermoplastic as an alternative material for orthotic springs
  - Lightweight
  - Financially feasible
  - Environmentally friendly
- Thermoplastics are sensitive to heating/cooling rates during the molding process
  - Change in mechanical properties due to
    - Degree of polymerization
    - Crystallinity degree
    - Chemical degradation
  - An accurate model of material and heat transfer is the key to uniformity of mechanical characteristics
- There is a need for a more durable and damage tolerant, pseudoductile composite



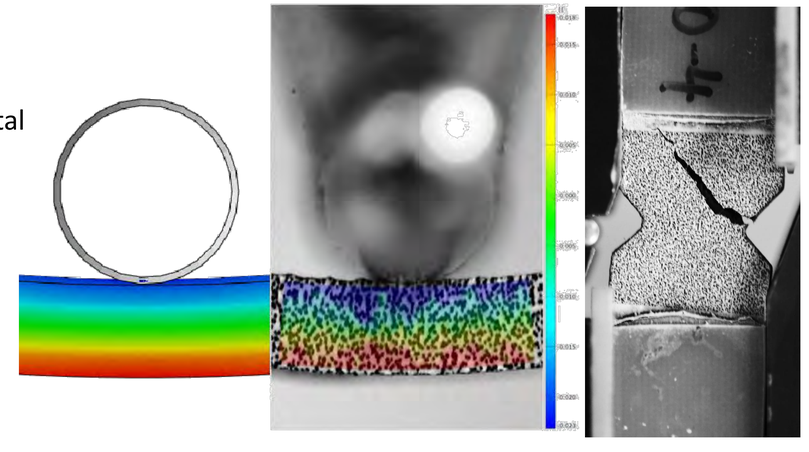


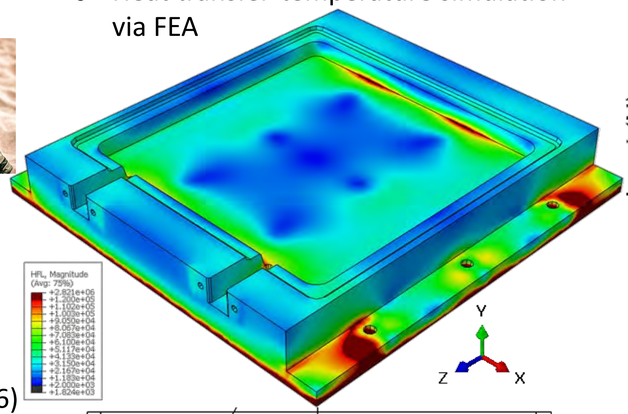
Innovation

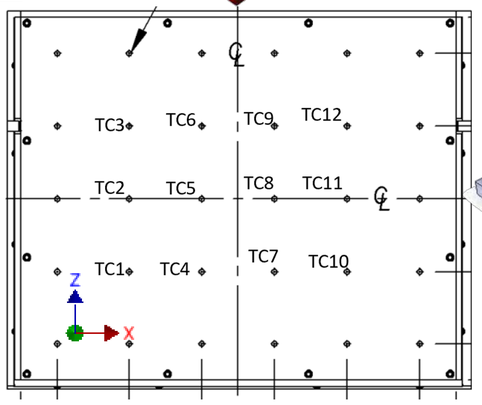
- Recycled composite fibers
  - Reduce waste by reclaiming used fibers
  - Lower cost compared to virgin fibers
- Compression molding of thermoplastic matrix (Nylon-6)
  - Compared to thermoset matrix (e.g. epoxy):
    - Easier and faster fabrication procedures
    - Lower labor demand
    - Less energy consumption
    - More bio- and chemical-degradable
- Orthotic spring advancement with rCF-Nylon-6
  - Lighter weight and more durable versus metal
  - Much more environmentally conscious than using virgin fibers and/or thermosets

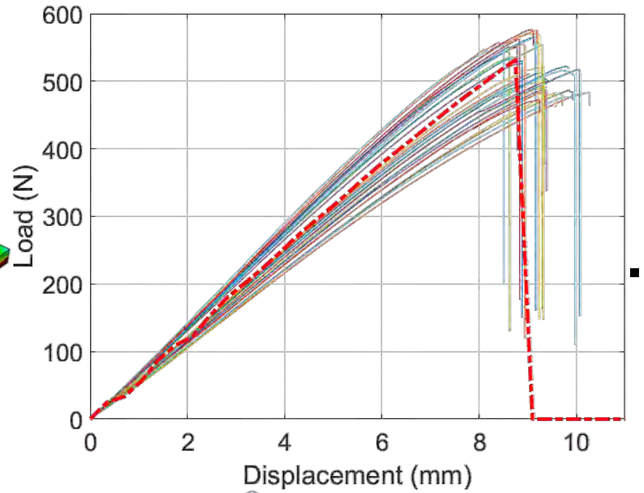
Project Description

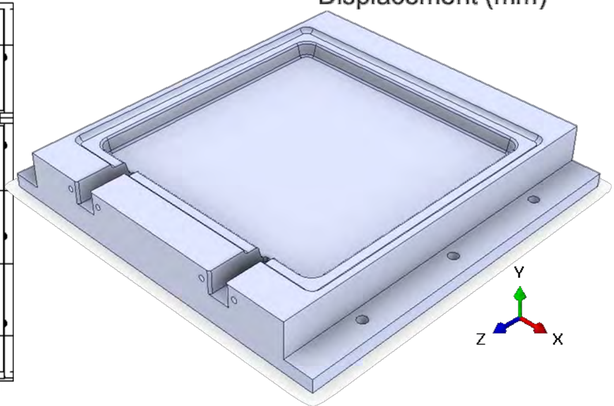
1. Create a useful material model
   - Digital scanning calorimeter characterization
   - Flexure and shear testing with digital image correlation (DIC)
   - FEA recreation of tests to verify material profile
   - Use FEA to determine potential of adding glass fiber tape to create more damage tolerant parts
2. Design a basic thermal model
   - Temperature profile measurement via thermocouple arrays
     - Interpolate and apply as BCs
   - Heat transfer-temperature simulation via FEA











Anticipated Impact

- *Clinical Patients*
  - Better overall experience
    - Lightweight
    - Comfortable
    - Affordable
    - Durable
- *Industry*
  - Developing new technologies for composite repurposing
  - Develop better models for thermoplastic composite processing
- *Environment*
  - Reclamation of carbon fibers
  - Recycling potential of thermoplastics vs thermosets
  - Reduction of manufacturing energy consumption

Path Forward

- Design and fabricate a small, trial orthotic tool
  - Design with inputs from the developed material and thermal models
  - Prediction of thermal and mechanical characteristics
  - Evaluation via mechanical tests and clinical trial
- Design a 24” x 24” orthotic tool capable of mass production
  - Larger format production tool
  - Financial feasibility evaluation
  - Modification of manufacturing processes