Flow Forming of Aerostructures

Student: Kyle Nelson, Supervisors: Alastair Conway, Kadir Paslioglu,
Industry Sponsor: David Milliken, Mykola Kulakov (Boeing)
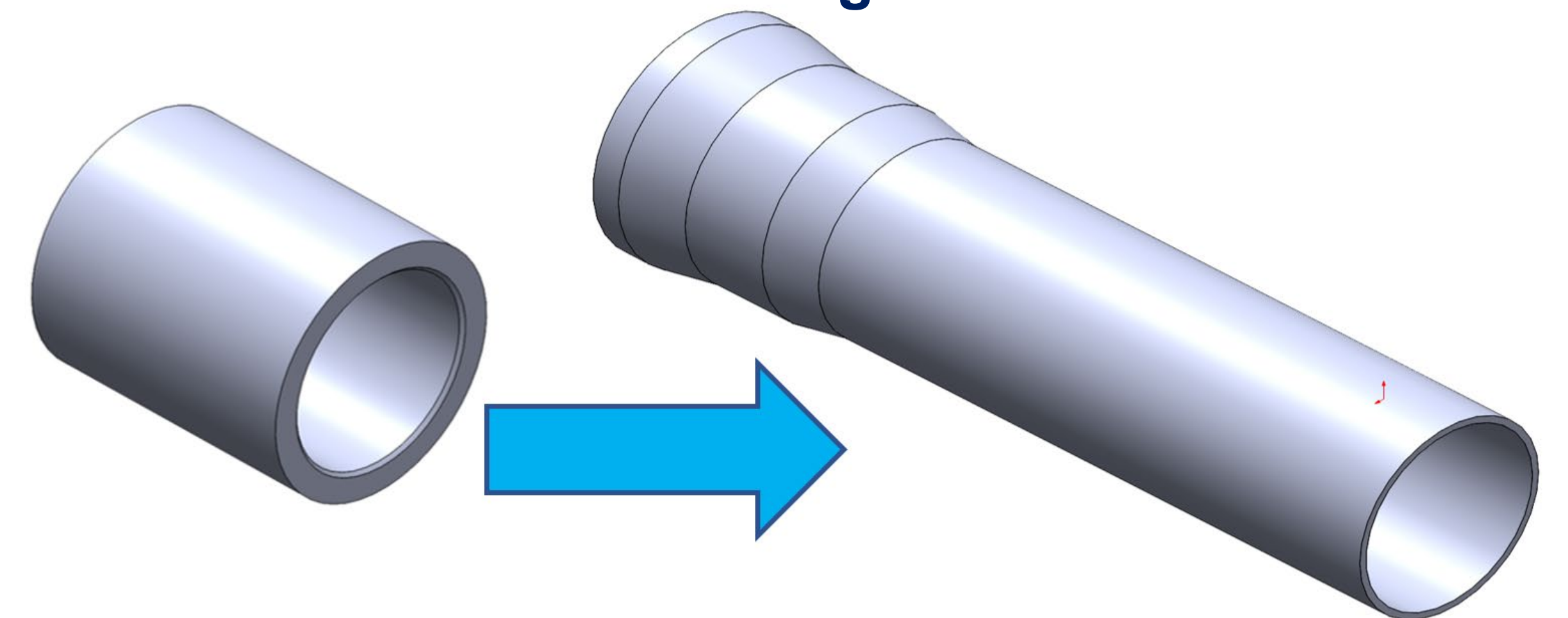
What is Flow Forming?

Flow forming, or metal spinning, transforms metal discs or tubes by rotating them and applying pressure, stretching the metal onto a mandrel for precision shapes. This method, rooted in centuries-old practices, stands at the intersection of art and technology, driving sustainable and efficient manufacturing forward.

Advantages of Flow Forming (Metal Spinning)

◎ **Material Efficiency -** Achieve shapes with less material

🫳 **Enhanced Grain Structure -** Boosts strength & ductility

✎ **Precision -** High accuracy & tight tolerances

◯ **Seamless Products -** Perfect for high-integrity needs

🪙 **Cost Savings -** Reduced tooling costs & waste

❈ **Superior Surface Finish -** Minimized extra finishing steps

🔧 **Flexibility -** Wide variety of shapes & sizes

🕐 **Shorter Lead Times -** Speedy production & reduced finishing

☑ **Cost-Effective -** Ideal for low to medium volumes

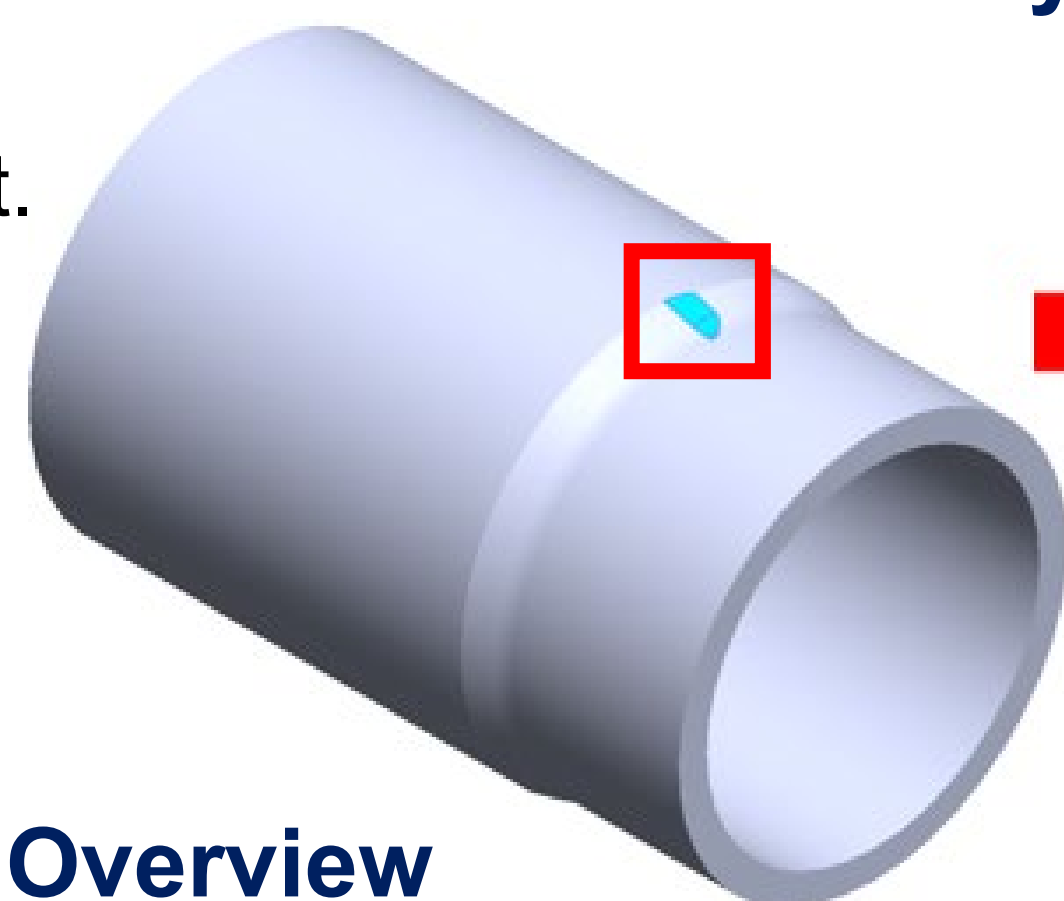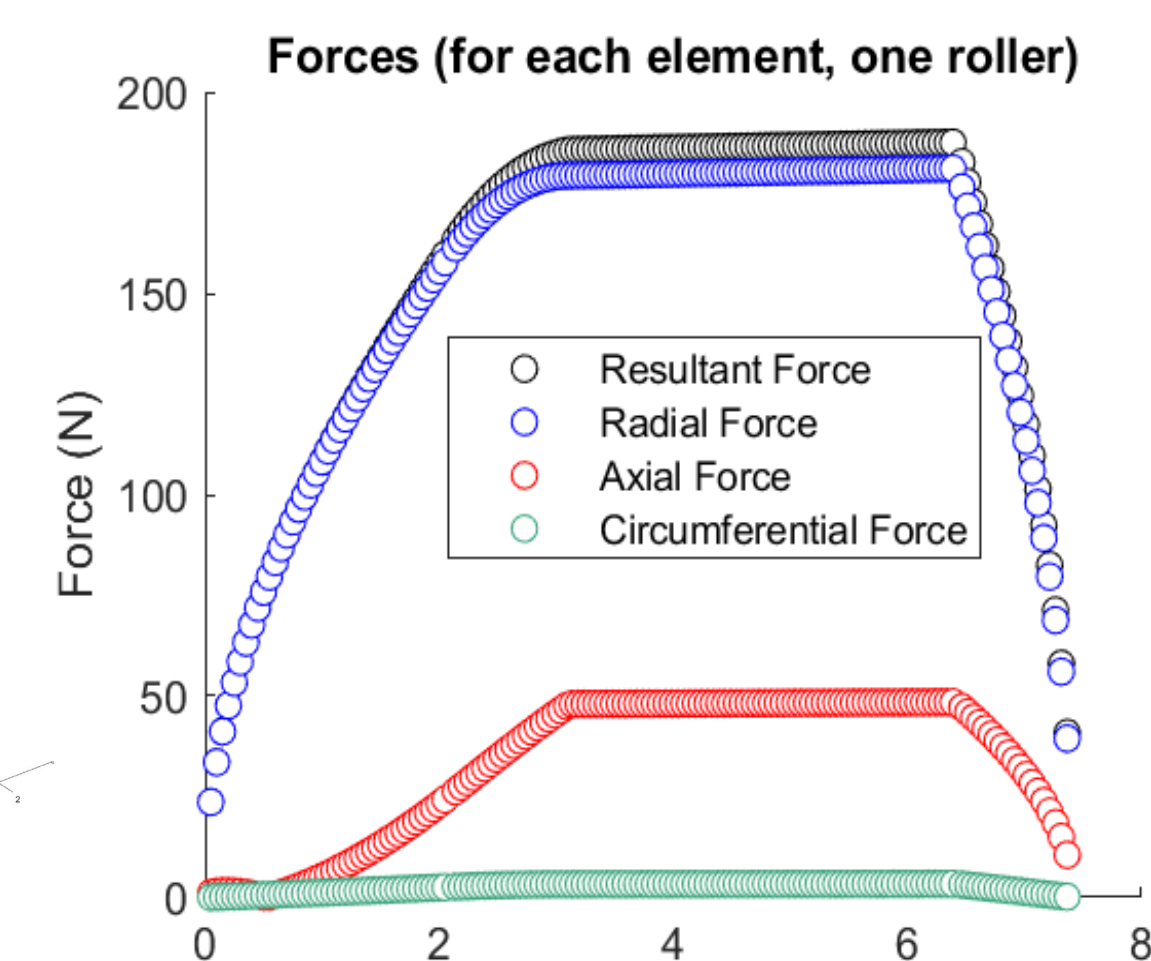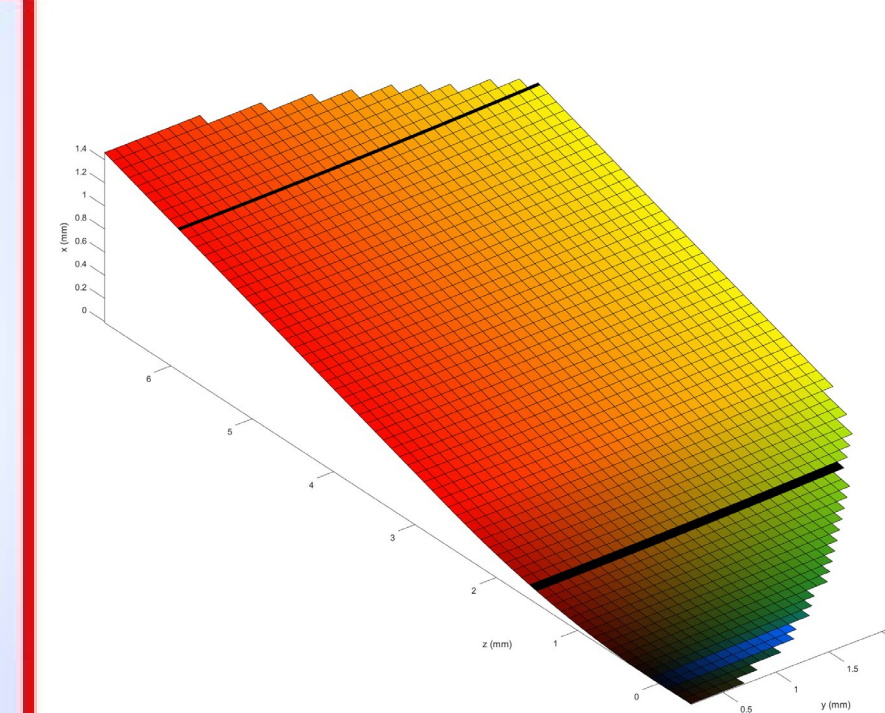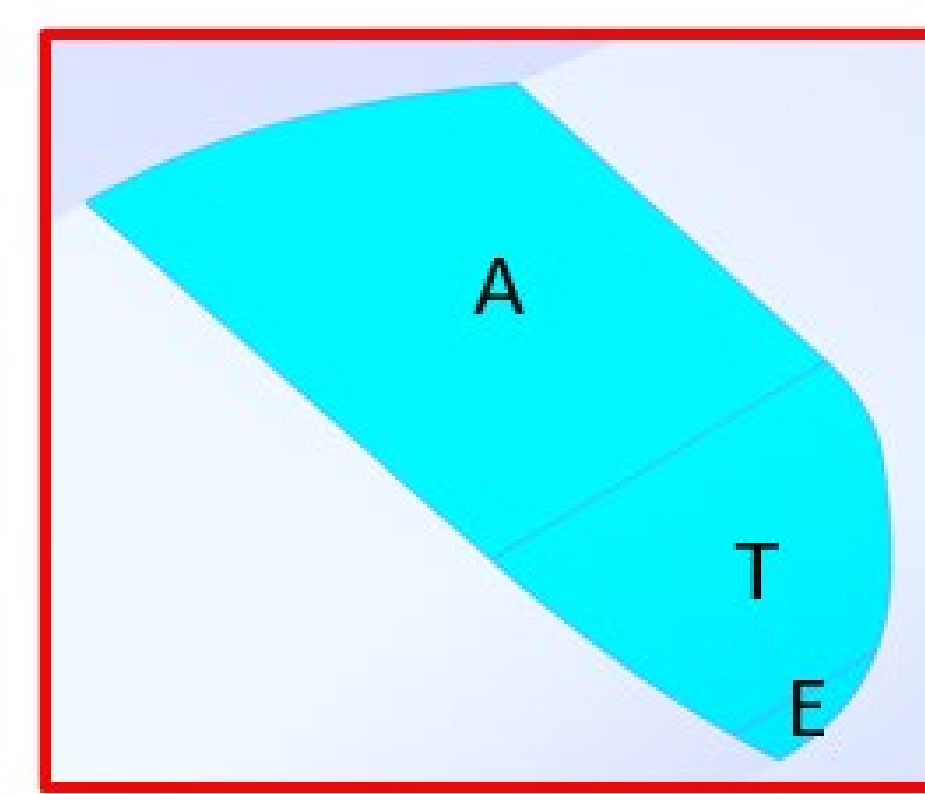💡 **Combination Friendly -** Pairs well with other processes

Challenges In Flow Forming

•Flow forming is complex by nature.
•Even slight changes in one parameter can drastically affect the end result.
•Difficult to develop a universal methodology.
  • Optimized settings for one material and shape may not work for another, even if the material is the same.
•Variability often requires a trial-and-error approach.
  • Can lead to material wastage.
  • Increases processing time.
•Numerous parameters influence the final product.
  • Tooling geometry
  • Part shape
  • Feed rate
  • Spindle speed

PhD Initiative on Flow Forming: Detailed Overview

•**Core Objective**:
  • Create a comprehensive analytical model for flow forming mechanics.
•**Analytical Model Highlights**:
  • Captures:
    • **Velocity Fields**: Speed and direction of material flow.
    • **Strain Rate Fields**: Understanding deformation rates.
    • **Power Metrics** & **Stress-States**: Analyzes energy and internal pressures.
  • Identifies defects, pointing out issues like imbalanced forces.
•**AI Integration**:
  • Incorporation of a **Feed Forward Neural Network**.
    • Processes data from the analytical model.
    • Provides real-time guidance on:
      • Tooling geometry.
      • Feed rate.
      • Spindle speed.
•**Benefits of Combined Approach**:
  • Merges traditional modeling with AI for precise, data-grounded predictions.
  • Helps in refining variables for optimal part formation.
•**Scalability**:
  • Model's insights from smaller components aid predictions for larger structures.
  • Offers potential for significant cost savings.

Flow Forming In Action

Before and After Flow Forming

Analytical Model with Artificial Intelligence

Forces (for each element, one roller)