Simulation of the overbraiding process using complex shaped mandrels

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Introduction - braiding

Braiding examples
Introduction

Circular braiding

Courtesy Eurocarbon, The Netherlands
Introduction

Spool movement

stem yarns

horn gear

warp (x)  weft (O)

Courtesy Eurocarbon, The Netherlands
Introduction

Process chain

- used for production of braided composite preforms,
- preforms are used for e.g. RTM (Resin Transfer Moulding) process,
- fiber material: dry or commingled thermoplastic
Introduction

Simulation of the overbraiding process using complex shaped mandrels

'Classical solution':

\[ \alpha = \arctan\left(\frac{\omega r_m}{v}\right) \]
Problem

Given:
- mandrel geometry,
- laminate plan with required $\alpha$,
- machine with constant carrier speed $\omega$:

How to automatically generate the take-up speed profile for an arbitrary mandrel?

$\alpha_{req} \rightarrow$ optimization $\rightarrow v$

...by inverse kinematics
Analysis - neglecting yarn interaction

Assumptions:
- no yarn interaction
- no friction at guide rings
- no slip after deposition
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From geometry,

\[ v = \omega \frac{\Delta z}{\Delta \varphi} \]
Experiment

Mismatch:
- model VS experiment
- Braid angle: 15° error
Analysis - including yarn interaction

Presumed main cause:
- “Neglect of yarn interaction”
Analysis - including yarn interaction

Assumptions:
- biaxial braid
- axisymmetry
- steady state

...by inverse kinematics
Analysis - including yarn interaction

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Analysis - including yarn interaction
Analysis result - including yarn interaction

- **no** interaction: straight yarns
- with interaction: curved yarns

130mm slack

220mm slack

goal: 100% coverage
Conclusions

- Significant braid angle error when neglecting yarn interaction.
- Including yarn interaction leads to a significant change in:
  - take-up speed profile,
  - predicted amount of yarn slack.
- Appropriate machine control required
Recommendations

- Validate axisymmetric yarn interaction model by experiment.
- Design and implement a yarn interaction model for forward solution (input: speeds, output: braid angle) for arbitrary shapes.
  - Coulomb / Howell friction
- Validate for arbitrary shapes.
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