Possibilities for preform production using the open reed weaving technology

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Overview

- ITA @ RWTH Aachen University
- Motivation
- Mechanical evaluation
- Method for economical evaluation
- Summary & future outlook
Overview

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- 38,000 Students in 130 courses of study
- 260 Institutes with 496 professorships
- 6,900 Employees (thereof 65% scientists)
- 788 Mio € Total budget, thereof:
- 315 Mio € Third party funding
The unique position of ITA

Comprehensive textile process chains

raw materials:
natural fibers, polymers,...

technology and competence fields

semi-finished textiles & products

Application fields

- mobility
- building & living
- health
- energy
ITA – Facts and Figures

Staff:
- 100 Scientists
- 55 Service personnel
- 190 Graduate research assistants
- 50 Students majoring in textile technology each year

Research and development
- Publicity and third party funded research
- Academic and industrial education

Development and transfer
- Direct industrial research
- Further education

Budget: ca. 14,3 Mio. €
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Process technologies for tailored textiles

Approach

- Application of “tailored” textiles
- Examples
  - Tailored NCF
  - Cetex
  - Tailored fiber placement
  - 3D weaving
  - Tailored braiding

Source: ITA, CETEX Chemnitz
Motivation

Production of FRP parts cost intensive

- Complex structures
- Multiple process steps
- High amounts of waste

Source: ITA, AVK
Motivation

Approach
- Application of “tailored” textiles
  - Local adaption of textile’s properties
  - Near net shape
- Advantages
  - Reduction of waste
  - Less cutting, handling and joining
- Examples
  - NCF with warp yarn shifting
  - Tailored NCF
  - Tailored fiber placement

Source: ITA, CETEX Chemnitz
Example: Tailored Open Reed Weaving

New approach: Open Reed Weaving

- Introduction of two additional yarn systems
- Possibility of local reinforcements

Source: Lindauer Dornier GmbH, Lindau
Motivation

Open Reed Weaving - Limitations

- Technology very new (developed in 2011)
- Lack of research:
  - Design possibilities
  - Mechanical potential of local reinforcements
  - Integration in preforming process chains
  - Applications

Objective

- Evaluation of mechanical potential for local reinforcements
- Method for economical evaluation in part design processes
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Mechanical evaluation

Approach

- Measuring effects of reinforcements on hole bearing resistance
- Two general reinforcement patterns
  - Knot-hole
  - X-Shape
- Additional variants of knot-hole
- Reference: sample without reinforcement

<table>
<thead>
<tr>
<th>Knot-hole variants</th>
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<tr>
<td>Standard</td>
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<td><img src="source" alt="Standard" /></td>
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Mechanical evaluation

Samples preparation

Geometry

Weaving

Reinforcement

Infusion

Cutting

Drilling

Reinforced fabric

Sample

Source: ITA
Mechanical evaluation - Testing of hole bearing resistance

Hole bearing tests according ISO 12815

- Upper clamp
- Distance plate
- Screwing
- Testing device
- Testing pin
- Sample
- Lower clamp

Source: ITA
Mechanical evaluation - Result analysis

Dislocated reinforcements
Crack propagation
Hole

Typical testing curve

Tested sample

Source: ITA
Mechanical evaluation - Results – maximum bearable strength

The bar chart illustrates the maximum bearable strength for different samples and orientations. The x-axis represents the type of sample: X-shape, Standard, Round, Double yarn, Distant, and Reference sample. The y-axis shows the maximum force in Newtons (N). The bar chart compares the force values at 90° and 0° orientations for each sample type.

Source: ITA
Mechanical evaluation - Conclusions test results

- Highest influence can be measured for energy absorption (up to 191 % enhancement)
- Improvement in bearable forces up to 110 %
- Knot-hole pattern leads to loop-like reinforcement in weft direction
- Avoiding of small radius to increase mechanical performance (notch effects)
- Increasing the number of reinforcing yarns leads to average improvement of 30 %
- Fiber crossing in X-shape pattern improves mechanical performance in warp direction significantly

→ Combination of X-shape and knot-hole promises best results
Method for economical evaluation

Motivation

- ORW offers a high potential for enhancing profitability of preforming process
- Cutting, handling and joining steps and waste can be reduced
- Existing cost calculation tools only cover preforming out of conventional textiles
  → Economic potential can not be evaluated so far!

Approach

- Method for designing fabrics with multiple local reinforcements, including
  - Cost calculation
  - Combination tool based on technological boundary conditions
  - Decision tool
Method for economical evaluation

Principle

- Identifying possible combinations of reinforcements
- Comparison to conventionally reinforced fabric

Reference preform: basic fabric + patches

Locally reinforced fabric

Source: ITA
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Summary & future outlook

Summary

- Potential for cost reduction by ORW
- No experience available for application of ORW for FRP
- Evaluating mechanical performance of local reinforcements by hole bearing tests
- Investigation of different reinforcement patterns
- Improvements up to 191% in absorbed energy measured
- Method for economical evaluation developed
  - Decision tool for best combination of reinforcements
  - Cost calculation and comparison

Future outlook

- Investigation of further load cases
- FEA simulation of reinforcements

Source: Lindauer Dornier GmbH, Lindau; ITA
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