RTM6 for Fixation of Dry Fiber Preforms and Auxiliary Materials

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Author: Somen Dutta
Speaker: Jan Faber
FIXATION WITH RTM6
MAKES PREFORMING FOR DRY FIBER PLACEMENT MORE ECONOMICAL
AND AVOIDS INFLUENCE OF ADDITIONAL EXTERNAL MATERIAL,
WHEN RTM6 IS USED FOR INFUSION
Motivation

Process: Dry fiber preforming + liquid resin infusion (RTM 6)
## Method selection

### Cohesive joining

<table>
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<tr>
<th>Method</th>
<th>Characteristics</th>
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| **Polyamid binder** (Spunfab Ltd.) | • Additional step for binder activation  
• Approved method for dry fiber preforming |
| **Adhesive tape, Saerfix EP** (Saertex GmbH) | • High friction coefficient and holding force  
• Chemical compatibility with resin needed  
• Not approved for airplane parts |
| **Spray adhesive, Aerofix 2** (R&G GmbH) | • Not approved for airplane structures  
• Difficult to implement in robotic production lanes (evaporation) |
| **Epoxy resin, RTM6**, (Hexcel) | • Standard infusion resin  
• High viscosity at room temperature  
• No additional adhesive needed  
• No visible impact on cured part |
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DLR Project PROTEC NSR – Highly automated manufacturing process

Continuous layers

Reinforcement layers

Continuous layers

Membrane & vacuum bag

Auxiliary materials for infusion

Integration of stringers
Preforming Process for Rear Pressure Bulkhead (RPB)

(a) Endless lay-up  
(b) Collaborative lay-up for large plies  
(c) Reinforcement plies
Requirements for Fixation – Theoretical characteristics

Friction force:
\[ F_f = F_G \times \sin \alpha \]

Parameters
- Areal weight of ply / preform
- Viscosity of resin
- Amount of resin
- Fixing area
- Pressure during application

Constellation of interest:
1. Preform-to-mould fixation
2. Layer-to-layer fixation
Evaluation of friction force

Diagram showing parts of the experiment:
- Load cell (1)
- Roving (2)
- CF plate (3)
- CF ply (4)
- Linear axis (6)
- Clamp (5)
- Guide pulley (7)

Diagram showing the relationship between measured force (N) and weight (Kg):
- Weight (Kg) on the y-axis
- Measured force (N) on the x-axis
- Points at (0, 0), (5, 1.66), (10, 3.32), (15, 5.43), and (20, 6)

Software used:
- PCE-FB Software
Requirements for Fixation – Parameters

- **Areal weight of ply / preform**
  - 372 g/m² (Priform, Cytec)

- **Viscosity of resin**
  - High viscosity at room temperature (~ 10 Pas)

- **Amount of resin**
  - As low as possible to avoid capillary effects

- **Lowest expected pressure**
  - for suction cups (end-effector for continuous plies)
  - 7,86 N/mm² / suction cup

- **Fixing area**
  - Limited by the size of the gripper system
RTM6 End-Effector

Nordson Controller

Extension with CFRP pipe and Witte profile

cartridge

Pneumatic spray nozzle

Spray nozzle

RTM6 in cartridge

Source: Nordson
Spray pattern - Generation

Use case 1
Continuous layers

Use case 2
Reinforcement layers

Use case 3
Auxiliary materials
Validation of use case 1 (Continuous layers)

(a) Fixation of 1\textsuperscript{st} CF-layers

(b) Fixed 59 CF-layers with RTM6
Validation of use case 3 (Auxiliary materials)

Deposition with multi-kinematic gripper

Fixed auxiliary packages
Summary

• Tota amount of resin: 1,2 kg

• Spray time CF layers: 11 hrs
  → Multiple nozzles would reduce time

• Spray time for auxiliary materials: 12 min

• No visible impact on cured part
Thank you!