Automation of Production Processes for CFRPs and Hybrids in Aerospace

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Outline

Intro: Center for Lightweight Production Technology, Augsburg

1. Fiber Metal Laminates for a fuselage side shell

2. Examples for robotic lay-up systems
   a. Gripper systems
   b. Lightning Strike Protection - Tapelaying for 90 cm multilayer tapes
   c. Autonomous cut-piece detection and path planning

3. Manufacturing and assembly of thermoplastic components

Summary
German Aerospace Center (DLR)

Locations and employees

About 8000 employees at 32 institutes and facilities at 16 sites.


Institute of Structures and Design Augsburg
Center for Lightweight Production Technology
Employees: 51
Turn over: 7 M€
Center for Lightweight Production Technology
Technology Readiness for Industrialisation

From material to prototype

Material
Design Structures
Manufacturing Demonstrators

TRL3
TRL4
TRL5
TRL6

DLR ZLP
Automated Production

Robotic, Mechatronics

From material to automated production

For integrated production development, industrialisation topics become more important
Flexible Automation Systems at ZLP Augsburg (1/2)

• High accuracy manipulation and calibration

• Simulation and offline-programming

• Reconfigurable and multi-functional systems

• Autonomous process guidance and manufacturing execution systems

• Various independent work cells, linkable to flexible cutter and logistics system
Flexible Automation Systems at ZLP Augsburg (2/2)

- Wickert 4400 S Composite Press
  - 1800 x 1200 mm²
  - 450°C
  - 100 - 4400 kN

- Krelus Infrared Heating System
  - 2000 x 1500 mm²
  - 20 – 800°C

- Kuka Robot KR210 R3100 Ultra F
  - Range  3100 mm
  - Payload  210 kg
  - Linear axis  5.4 m
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Summary
1) Fiber Metal Laminates for a fuselage side shell

Status quo:
• Manual manufacturing process of a FML layup
• Post-manufacturing QA

Targets:
• Automation of aluminium layup
• Integration of glass prepreg and adhesive layup
• Integrated QA and automated assessment

Quelle: PAG
1) Fiber Metal Laminates for a fuselage side shell

Aluminium layup

Schematic of gripper positions and movements for cooperating robots

Transfer strategy
1) Fiber Metal Laminates for a fuselage side shell
Aluminium layup
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Summary
2a) Examples for robotic lay-up systems
Gripper systems and draping strategies

- Target component: pressure bulkhead
  - Double curvature with radii 1.3 – 3.3 m
  - Overall dimensions 3.5 x 4.0 m

- Thermoset part
  - Female Tooling
  - Preform made of dry textiles & stiffeners
  - 25 cut-pieces vary in size & geometry
2a) Examples for robotic lay-up systems
Gripper systems and draping strategies

Partners: Fraunhofer IWU-RMV, Schmalz GmbH
2b) Examples for robotic lay-up systems
Tapelayer for 90 cm lightning strike protection

Material width
90 cm

Cut piece length 4 m – 6 m

Layup 3D

Flatening 2D
2b) Examples for robotic lay-up systems
Tapelayer for 90 cm lightning strike protection

- 3 layer material (carrier, prepreg, foil cover)
- Prepreg made of copper mesh and thermoset matrix
- High draping forces required on doubly curved surfaces
- Compression results in waviness or even folds
2b) Examples for robotic lay-up systems
Tapelayer development
2b) Examples for robotic lay-up systems
Tapelayer development

Implementation in robotic cell and pre-testing

Implementation of sensors and controls

Validation on full-scale female demonstrator

Development of robotic path planning

Transfer of lay-up to female geometry

Reconfiguration
2c) Examples for robotic lay-up systems

Autonomous Gripper

Challenge:
- Process chains not fully automated
- Provide textile cut-pieces with high accuracy
- Robust pick-and-place process

Goal:
- Flexibility and robustness in an intelligent system

Requirements:
- No obstacles
- Wide field of view
- Independent from ambient light
- Independent from reflections on cut-piece surface
- Closed casing to protect from carbon fibers
2c) Examples for robotic lay-up systems

Template-Matching for rotating Objects

- Produce rotating bitmaps from CAD-data (plybook)
- Comparison to camera view
- Advantage: Robustness regarding waviness and reflections
2c) Examples for robotic lay-up systems

- Automated camera based ply-detection
- End effector for the automated stacking of tailored laminates
- Ultrasonic spot welding of laminate stacks
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Summary
3) Manufacturing + Assembly of Thermoplastic Components

Use Case: Sine Wave Beam

- Sine wave beam as generic crash-absorber to demonstrate entire process chain from design to automated production

- Assembly of sine wave beam consists of 7 parts with 3 different geometries with high degree of deformation

[Kindervater and Georgi, 1993]
3) Manufacturing + Assembly of Thermoplastic Components

Automated Clamping Frame
3) Manufacturing + Assembly of Thermoplastic Components

Resistance Welding

- Resistance welding of CF/PEI parts for the sine wave beam assembly
- Test stand to establish process parameters at the Institute of Structures and Design (DLR BT) in Stuttgart
- Welding element made of stainless steel glassfiber semipreg developed at DLR BT in Stuttgart
Summary

1. Automation of production processes in Aerospace
   a. Production rates of 10 – 60 per month
   b. Dimensions with variability 0.5 – 10.0 m
   c. Accuracy in layups regarding positions and fiber angles

2. Shown examples
   a. Fiber Metal Laminates for a fuselage side shell
   b. Draping systems for double curvature
   c. Tape layer for 90 cm multilayer tapes
   d. Autonomous cut-piece detection and path planning
   e. Manufacturing and assembly of thermoplastic components
Acknowledgements

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