Continuous High Volume Part Production Technologies

Innovation Day 31.05.2016
Agenda

- CTC
- Continuous Profile Production – Part Portfolio
- Continuous Profile Production – Technologies
Composite Technology Centre Stade (CTC)

Product Life Cycle

-10 years
TRL 2
Academic research

-4 years
TRL 4
End-user oriented research

Start of production
TRL 6
Preparation for serial production

+ 20 years
Serial production
End of life

Aircraft maturity level

OEM
CTC GmbH
CFK Nord
Recycling Company

CFK Nord
CTC GmbH
OEM
Recycling Company

CFK VALLEY STADE
niedersächsische technische hochschule

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- CTC
- Continuous Profile Production – Part Portfolio
- Continuous Profile Production – Technologies
Continuous Profile Production – Part Portfolio
General Overview

Fuselage
VTP / HTP
Wing

Floor Structure
Frames
Rib
Stringer

A320  A330  A340  A350  A380
Continuous Profile Production – Part Portfolio
CFRP Fuselage Frames

A350 XWB

Typical Frame
- potential rate: **13** a/c per month
- high level of variants

→ **~ 50,000** frames/year

NSR

Typical Frame
- potential rate: **60** a/c per month
- low level of variants

→ **~ 150,000** frames/year
Assumptions

- Rate: 60 ac/month from 2019

- Stringer:
  - 100m T-stringer per VTP centerbox

  → 6,000m T stringer per month
  → 70 km T stringer per year
Assumptions

- Rate: 60 ac/month
- Part: 2 x wing upper cover + 2 x wing lower cover per ac
  \[ \rightarrow 240 \text{ WUC+WLC /month} \]
- Stringer:
  - 11 stringer per WUC + 10 stringer per WLC
  - \( \sim 100 \text{ m stringer per WUC} + \sim 80 \text{ m per WLC} \)
  \[ \rightarrow 21.600\text{m stringer per month} \]
**Geometry** (example fuselage frame)

- **R1 ≠ R2**
- **variable web high**
- **0° plies web**
- **0° plies flange(s)**
- **local reinforcement (web and/or flanges(s))**
- **global reinforcement (web and/or flanges(s))**
- **twist**

**Key Characteristics**

- Fiber-Angle-Deviation
due to:
  - Geometry- / Process- / Reproducing- Factors
- Ondulation
- Gaps / Overlaps
- Thickness-Tolerance
- Contour Tolerance
- Reproducibility
- **€/kg**
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Continuous Profile Production – Technologies
What profiles can we buy today and where we want to go

- **Continuous/high volume**
- **Discontinuous/Small volumes**

- **Simple**
- **Complex**

- Manual labour dominated, high production cost
  - e.g. A350 fuselage frame

- Full automation for complex products
  - UD & multiaxial textile
  - Local patches
  - Web height variation
  - Fast and/or continuous impregnation

- **UD Pultrusion profiles**
  *1) Image source: DPP (vDijk Pultrusion Products)
  *2) Image source: Maschinenmarkt (Thomas Technik)
Continuous Profile Production – Technologies
CTC – Portfolio

- 3D Preforming (LOKOST) for complex, curved profiles → Frames
- PRTM for complex profiles → Stringer
- RTM Auto-RTM
- RTM HP-RTM

Manufacturing Feasibility Evaluation (NCF & Prepreg): Typical-Frame & Door Frame
Generic, NSR, A350-900, A350-1000
Barrel Test-Part Manufacturing
Barrel 1b, Barrel 1bR2

Technology Specific
NCF
Part Specific
Prepreg
Continuous Profile Production – Technologies
CFRP Profile Production Line - Frames

- Fully Automated Process Chain
- Variable Continuous 3D Preforming
- High-Pressure-Auto-RTM

LoKost 1.0 plant

LoKost 2.0 plant

High-Pressure RTM

Preforming

Curing

Net-Shape Part

Auto-RTM

CTC Auto-RTM

DLR Evo

Evo
Continuous Profile Production – Technologies
CFRP Profile Production Line - Frames

LoKost 1.0: Automated 3D Preforming
Variably curved Z- and LCF-profile preforms

LoKost 2.0: Automated complex 3D Preforming
Variably curved omega-profile preforms with interleaved patches and variation in the cross-section

- Basic preforming system for continuous preforming
- Curved preforming
- Variable curvature
- Global patch integration
- Local patch integration
- Web height variation
- In-line quality check for single textile layer
- In-line cutting
- Automated handling of preforms
Continuous Profile Production – Technologies
Comparison of processing rates for complex profiles

Productivity bottleneck with current production systems
Continuous Profile Production – Technologies
High Pressure RTM Technology

Target
Development and Enhancements of High-Pressure-RTM Technology (HP-RTM) for Aeronautical Application

- technology feasibility validation for aerospace part production (→ aerospace quality requirements)
- process-time reduction for RTM-Part production from today ~3hrs to ~15 min
  - aerospace adapted fast curing 2K epoxy resin
  - innovative injection strategies and technologies
  - internal release agent application
  - isotherm process, no heating no cooling rates
  - mixing head mounted to tool, no cleaning of neat resin
CTC HD-RTM

- KraussMaffei RIM Star Thermo
- 2 mixing heads, multipoint injection
- 250t press
- 2.5m x 1.5m press bolster
- 15kW Heating / Cooling system
- Compression RTM capable
- Qualified staff

Z-Frame Tool

- Straight Z-Frame, length 1200mm
- Applicable for 4-pt-bending test-part production
- Applicable for manufacturing feasibility demonstrator part production

Coupon Tool

- Coupon t=2mm
- Applicable for typical tests (e.g. CAI, ILSS)
- Applicable for generic analyses
Fully Automated Process Chain
Variable Continuous 2D & 3D Profile Manufacturing
Preforms, Net-Shape Prepreg Profiles and Fully Cured Parts
Continuous Profile Production – Technologies
CFRP Profile Production Line - Stringer

Pultrusion + RTM
Continuous Profile Production – Technologies
CFRP Profile Production Line - Stringer

Manufacturing Throughput per Line:
Jamco ADP prepreg stringer: up to 2m per hour*
PRTM textile stringer: more than 18m per hour

Summary:
- significant part cost reduction through increase of manufacturing speed by a factor of 10
- manufacturing and material technology applicable to many part families (stringer, beams, struts)
- no internal release agent, potential weight reduction (NCF instead of woven fabric)

*: Source: Patent DE 102007018052 A1
Continuous Profile Production – Technologies
CFRP Profile Production Line – Prepreg Frame

- Heating device
- Conical rolls
- Storage roll with break prepared material
- Biax-material preparation
- Sub-preforming
- Preforming
- Curing
- UD-material preparation

- Heating device
- Hand wheel
- Propulsion rolls
DryFibre Wing of the Future (WotF)

Profile Production

Example: CFRP Profile Production Line

Example: Prepreg Process Chain

Profile Integration

Example: AutoVac
Marketplace and Facility Demonstration CTC

LoKost 1.0: Automated 3D Preforming

LoKost 2.0: Automated complex 3D Preforming

PRTM

HP-RTM