Smart production technology for complex carbon composites

Cevotec | APAC Innovation Summit AM & PE
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Carbon composites – from (aero) space to our daily lives!

Yet development and production are problematic

- Complex composites are still manufactured by hand
- Development and production require specialists
- Production cycles take too long
New technology for automated production of complex composites

+ 

User-friendly software for rapid product development
The Cevotec solution: Breaking down complexity!
Fiber Patch Placement ★ additive manufacturing for composites

Innovation
- Truly additive manufacturing
- Industry 4.0
- Perfect symphony of software & hardware
- 15 man-years of development work (w/ Airbus, TU Munich, et al.)

Benefits
- 150% higher strength & stiffness
- 25% less material & weight
- Unique design and aesthetics

Fiber Patch Placement

Main applications

Complex geometry products

Complex fiber reinforcements for ANY composite product

end-to-end automation | high quality | high volumes  
reduce weight & cost | increase mechanical properties
Rapid development + efficient production + better products

Use Case: complex reinforcements
Example: kiteboard

Without Cevotec

With Cevotec

Rapid product development
· Easy change of layouts
· Results can be simulated
→ Quick iterations

Efficient production
· 0% scrap
· 80% time reduction
→ Tailored reinforcement

Better boards
· Better mechanical properties
· Great optics
→ Higher margins
The Cevotec business model
One-stop-shop for patch-based production technology

Today
Technology as a service

Development
Manufacturing

Development & production of customer-specific parts
Market entry, awareness & technology adoption

2017 launch:
Production equipment & software

Software
Hardware

Equipment sales, software licenses, consumables
Long-term business model

Focus of business activity (illustrative)


Technology services
Equipment and software
Felix Michl (Dipl.-Ing.)
Technology
- Co-developed the FPP technology
- Aerospace engineer
- 8 years composite experience

Dr. Neven Majic (Dr.-Ing.)
Software and Digital Product Development
- Ph.D. in structural simulation
- 8 years composite experience

Thorsten Gröne (MBA)
Business
- MBA from IESE and UC Berkeley
- 8 years strategy consulting
- Expert project management skills

Mentor & advisor
Prof. Klaus Drechsler

Professional & academic experiences of the team

BOSCH
Berkeley Haas
Universität Stuttgart

IESE
TECOSIM
Monitor Deloitte

J.P. Morgan
German Aerospace Center

KIT
TUM
Technische Universität München
SAMBA - industrial Fiber Patch Placement production system
Available in March 2017

MARKET LAUNCH
JEC World
Paris
March 14-16, 2017
ARTIST STUDIO - engineering software for Fiber Patch Placement
Available in March 2017

Artist Studio
Standalone CAD-CAM Software with two modules

Module Patch Artist
Generation of high performance FPP laminates

Module Motion Artist
Generation of production data

Outlook: Additional modules with FE-based functionalities to be added in future versions of Artist Studio
Composite production line with Fiber Patch Placement
Integration of patch technology into industrial composite lines
Composite production line of the future – prototype in NL

Airborne and Siemens built digital factory in the Netherlands (Dec 2015)

Source: Airborne (http://www.airborne.com/airborne-and-siemens-build-digital-factory/)
milestones in composites
Fiber Patch Placement prototype system

https://www.youtube.com/watch?v=35V5exLR9IA
The concept behind the story

Why Patch Placement works so well, scientific results, and details of implementation
Bionic lightweight design
Motivation for Fiber Patch Placement

Natural Fibrous Structures
- Leaf
- Tree trunk
- Human bone

Technical Structures
- Hall construction airport Stuttgart
- Topology optimized chassis
- Curvilinear carbon fiber orientation

Fibers follow curved paths

- Transferring the principle for lightweight construction
- New curvilinear textile technologies
- **Fiber Patch Placement**
  Direct patch placement on 3D geometry or along 3D load paths
Massive drop in strength in classical laminates
Most problematic aspect of multiaxial non-crimp fabrics

Fact
Multiaxial non-crimp fabrics such as quasi-isotropic lay-ups cannot exploit the full potential of the material.

Example
45° deviation to a tension-based load path leads to an extremely reduced strength (>90%)

→ No optimal lightweight design

Unidirectional properties of patch laminates
FPP UD strength: 65% – 80%  |  FPP UD stiffness: 85% – 90%  |  compared to UD endless fiber
Strength increase of FPP due to curvilinear fiber orientation

Demonstration at an open hole specimen

Biaxial non-crimp fabrics

Load path oriented fibers (FPP basis)

Mass-specific maximum strength

+120%

Stiffness increase through load optimized fiber laminate

Measured test results

Source: Cevotec and Technische Universität München
Patch reinforcements improve conventional lay-ups
Load-path oriented reinforcements reduce material, weight and cost

Quasi-isotropic lay-up

Lay-up with FPP patch layers

8 unidirectional layers

4 unidirectional layers + 2 FPP Lagen

20% weight reduction
Laminat design software
Optimal splice distribution key to performance

Unoptimized patch laminate

Optimized patch laminate
The virtual FPP process chain
From design to preform in an integrated process

**CAD design**
- Spacially curved surfaces
- Concave & convex
- Undercuts possible

**Laminate design**
- Curvilinear fiber orientation
- Patch laminate optimization algorithm
- Optimal distribution of splices

**Process simulation**
- Simulation of robot movements
- Feasability check
- Offline machine programming

**Automated preforming**
- Fully automated process from tape to preform
- Automated preform handling and removal
In composite production, **complexity** is the enemy of **automation**

- Complex 3D geometry
- Complex curvilinear fiber architecture

How to deal with **complexity** in composite production?
The Cevotec solution
Fiber Patch Placement (FPP) – additive manufacturing for composites

Five steps. Endless advantages.

1. Feed dry, bindered CF spread tow and inspect quality
2. Cut spread tow into fiber patches
3. Inspect fiber patch quality
4. Pick up patch, check patch position
5. Position patch on 3D preforming tool
Fiber Patch Placement
Five steps. Endless advantages. Truly additive manufacturing for composites.

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Five steps. Endless advantages. Truly additive manufacturing for composites.

1. [Diagram step 1]
2. [Diagram step 2]
3. [Diagram step 3]
4. [Diagram step 4]
5. [Diagram step 5]

4. Pick up patch, check patch position
Fiber Patch Placement
Five steps. Endless advantages. Truly additive manufacturing for composites.

5. Position patch on 3D preforming tool
Looking for: Manufacturing innovators to bring their products to the next level with patch placement technology!

Offering: Evaluation, feasibility studies, prototyping services ► production systems, software & support

Supported by:
Annex
Medical orthosis

Sample application

Medical orthosis

- Advanced geometry
- Undercuts
- Small radii
- Net-shape preforming
- Local thickening at critical areas
- Tailored stiffness by fiber design
- 10 cooperating robot axis for direct 3D preforming
Bicycle saddle
Sample application

FPP bicycle saddle

- Extreme low weight (<70 g)
- Unique and attractive optic
- Net shape preforming
- Local thickening at critical areas
- Stiffness tailored to customer requirements
Local reinforcement for holes / joints

Sample application

Shear stress reinforcement

- Extreme low weight (1-3 g)
- Unique and attractive optic
- No material scrap during manufacturing
- Very good load distribution in component
- Higher increase of bearing strengths compared to conventional reinforcements
- Geometry tailored to customer requirements

Image source: Airbus Group
Unique design and aesthetics
Sample application

FPP bicycle saddle

- Radially arranged, 60mm long patches with round cutting edge

Scale-like pattern

- Tri-directional patch orientation
- Variable patch length with straight cutting edge
Smart production technology for complex carbon composites

- Innovation in composite production: Fiber Patch Placement
- Broad range of applications in large and growing composites market
- Production systems, design software, services ► Cevotec

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