Automation in production integrated NDT using thermography
NDT in Aerospace - Augsburg 2012

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- Introduction
- State of the Art in Aerospace
- Challenges for NDT
- Approach – production integrated, automated Thermography as a choice
- Realisation
- Conclusion
DLR Center for Lightweight Production Technology

ZLP Site Stade

ZLP Site Augsburg
Objectives: Maximum floor-to-floor efficiency by high placement rate and robust placement devices at a **highest quality level**

Placement rate: > 100 kg/h

**Augsburg**
- Robot based textile placement
- VARI, VAP & Thermoplastics
- Production-Integrated QA

**Stade**
- Parallel automated fiber placement devices
- Autoclave technology with integrated process control
Composite Production Technology @ ZLP Augsburg
Enablers for integrated process development

- Materials & Processes
- Handling devices
- Placement devices
- Tooling concepts
- ...

- Development of QA strategies
- Assessment of NDT methods
- Integration of NDT and corrections
- Data management for closed loop
- ...

All enablers are inseparably linked to get an optimised composite production
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State of the art in aerospace
Present production and quality strategy (large components)

Present process chain dominated by manual work incl. human senses with one physical quality check (NDT) at the end
State of the art NDT in aerospace

- Water coupled ultrasonic inspection
  - Submersion technology
  - Squirter technology
  - Sampled Phased Array
  - Transmission and Impuls/Echo
- Gantry solutions with linear and rotational axis

Sources: National Composites Network, Premium Aerotec, IntelligeNDT, HPI
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Challenges for NDT
Improving production and quality strategy

- Quality
  - Improved rework rate
  - Detailed documentation (engineering loop & continuous improvement)
  - Control proper quality indicators

- Cost efficiency
  - Improved output rate (parts/h)
  - Improved rework rate
  - Final quality check on samples → to be certified
  - Higher degree of automation → optimum to be adapted to SOA
  - Enable continuous improvement

→ Integrated production and quality assurance rather than local improvements

Automated production with integrated QA is needed to meet market expectations
Challenges for NDT
Future production and quality strategy

Future process chain needs optimised degree of automation with integrated physical quality checks along the process.
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Approach – production integrated, automated Thermography as a choice

Objectives:  
- Reduction of QA cost (today 20% of component RC)  
- Reduction of QA lead time  
- Reduction of rework after final NDT check  
- Integration into manufacturing process  
- Achievement of robust processes

- Point-to-point analysis along production chain  
- Thermography as a contactless method  
- Able to measure textile preforms as well as cured composite parts  
- Failure analysis and interpretation  
- Defect localization even on large structures

Integrated QA is a key factor for cost efficient, high quality composite production
Production integrated, automated Thermography
Optically excited Lockin-Thermography

(a) Missing Roving  (b) Fuzzball

(c) Roving orientation on curved parts

Source: edevis  Source: DLR

Ply location & orientation
Rovings‘ orientation

2D- Defects
3D- Defects with limitations

NDT methods need just the right abilities to deliver the specified quality
Potential defects
At preform stage

Roving gaps

Roving accumulation
Potential defects
Cured parts

Delaminations
Porosity
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Realisation
Integration into Manufacturing Cell (MFZ)

Flexible infrastructure for a wide range of lightweight structure production technologies

Source: DLR/KUKA
Realisation
Integration into Manufacturing Cell (MFZ)

Flexible infrastructure for a wide range of lightweight structure production technologies
Realization
Principal design of a thermography system
Realization
Evaluation on multiple Scenarios

Advantage
• Easy to integrate in robotic cell
• Measurement & data analysis in real time

Drawback
• To locate the center of gravity of endeffector→robot inaccuracy
• Required more than 50m long cable for data transmission
• No more flexible enough to measure complex parts
• Required special heavy weight robot
Realization
Evaluation on multiple Scenarios

Advantage
- Measurement & data analysis in real time
- Accessibility through lean end effector
- Less change to existing configuration
- High system accuracy due to low weight and moment of inertia

Drawback
- Requires more than 50m long cable for data transmission
- Complex solution to integrate into large robotic working cell (MFZ)
Realization
System Integration

KRC
EC Master

EtherCAT

CPU
EC Master
TwinCAT PLC
Runtime
With
Master-Master
Bridge

EtherCAT

Thermography system

EtherCAT Slave card

TWIN CAT I/O
C++
C#

Display/MG
Experimental tools: Concept of measurement scenario
Automation along the process chain
Process preparation for quality check

- Cutting
- Handling, Preforming
- Vacuum bagging
- Infusion
- Debaggign, Demoulding
- NDT Quality Check
- Machining, Assembly

Automated QA by means of Thermography

Feedback to Engineering

Data Evaluation → Scrap Parts

Measurement → Input for Measurement Software

Offline Programming for Final QA → Measurement Strategy
Offline Programming
Offline Programming
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Conclusion

- Enormous challenges ahead for lightweight structure production
  - Need for cost efficient composite production for aircraft Industry
    → automation of production and quality assurance
  - Steep and robust ramp-up essential for future aircraft programs
    → mitigation of industrial risks
  - Increasing rate of aircrafts and parts to be expected

- Local improvements in quality assurance are not sufficient to fulfill needs
  - Next step of innovation: Integration and overall optimization of processes
  - New production, quality (and engineering) strategies to be developed
  - Emphasize research on relevant process sensitivities

- Facing the challenges
  - Know-How & Infrastructure being built to cover required technology readiness level
  - Production processes and integrated QA are permanently under development
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