Human Aided Automation – a Game Changing Chance for the Aerospace Industry

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Motivated by the Digitization Initiative of the German Government
DLR – German Aerospace Center
Sites and Staff

- 8,500 employees
- 42 Institutes and Institutions
- 20 Sites

Institute of Composite Structures and Adaptive Systems
Fundamental Materials Research (e.g., novel resins)

20,000 qm for cooperation and innovation
The R&D-environment of the CFK-Valley Stade
**Digital Twins**
Accurate digital models represent both the product and the optimized production processes, saving costs, time and engineering efforts.

**Digital Guidance**
Mass customization is a cornerstone in future manufacturing. Digital Guidance helps to minimize set-up times by autonomously adapting facilities and controlling workflows.

**Autonomous Assembly**
Intelligent autonomous robots assemble individually customized products using advanced planning algorithms, sensors and modular adaptive robotic skills.

**Additive Manufacturing**
Data analysis and digital tools improve manufacturing methods resulting in complex and individual parts with optimized geometries and improved component properties.

**Human-Robot Collaboration**
Intelligent robotic assistants and their human co-workers interact via intuitive, multi-modal programming interfaces and share their workspace in safe and efficient industrial applications.

**Mobile Manipulation**
Mobile autonomous production units fitted for carrying out a variety of back-work-like tasks help to overcome static shop floor layouts.
The DLR Center for Lightweight Production Technology (ZLP)

Objectives: Maximum floor-to-floor efficiency by high placement rate and robust placement devices
Placement rate: > 100 kg/h → industrial scale up to TRL 6

Stade
Multi-robot automated fiber placement
Autoclave technology
Fully automated preforming and RTM

Augsburg
Robot based dry placement of multi-axial fabrics
Vacuum infusion (VARI, VAP), oven curing

Future Factory labs for Composites
Future Factory for Composites

How does it look like?
Multi-Head Automated Fiber Placement
Smart and efficient autoclave processing

- The Virtual Autoclave – a digital twin of the real process

Simulation of heat flow inside the autoclave
Fully automated textile preforming and RTM-production

1. textile storage
2. textile cutting
3. textile handling
4. draping
5. compressing
6. trimming to net shape
7. loading/10. demoulding
8. isothermal 2C injection
9. curing
Fully automated textile preforming and RTM-production

• Example for demonstrator which has been produced by fully automated textile preforming and RTM-process: generic VTP-Rip

Today cycle time is limited to 25 min. due to curing time of qualified resin system
Over-automation: “Production Hell”

Elon Musk:
• Too many robots in the production process of the Model 3 led to
• "crazy, complex network of conveyor belts“.
• Robots slowed down production
• Start using more humans in the factory, to speed up production

Short way out:
• Take personally control over production line
• Sleep at the factory to keep it running

Learning element for Industry 4.0:
• Where are human skills indispensable?

Why does Human Aided Automation work for Composite Production?

- In Composite Production possible sources of errors are very individual.
- You can’t step into fully automated processes physically to detect a problem...
  ... virtually, you can!
- In case-by-case decisions humans are superior to computers.
- Automation suspends humans from interaction, digitization brings humans back to involvement.
HR: Human Aided Automation

- Reinvolve Human into Automation
- Smart Remote Maintenance
  - VR-login for service provider
  - AR for on-site worker
- Process Monitoring
  - Process data displayed in the right context
- Collaborative Troubleshooting
  - Multi User VR/AR
- „Replay“ as process documentation
  - Review process as happened
  - Walk through instead of one-perspective video
"Human Centered Digitization" in lightweight construction

Manufacture of substructures:

- Individual correction of process- and material tolerances
- Production and assembly conform
- Design with weighted tolerance windows

Assembly of substructures:

- Usage of elasticity and plasticity for gap avoidance

Interactive correction of processes:

- Measurement of:
  - Fiber angle,
  - Flow front,
  - Part thickness,
  - Curing state,
  - …
- Actuation of:
  - Forming angles,
  - Pressures,
  - Temperatures,
  - Valves,
  - …

Interactive Joining of substructures:

- Measurement of:
  - Surfaces,
  - Clearances,
  - Joining Forces,
  - Adhesive Distribution,
  - …
- Actuation of:
  - Treatment,
  - Positioning,
  - Compression,
  - Dwell Time,
  - …

- Reduced process time
- Minimized scrap rate
- Inherent development
- Relaxation of specifications

Learning aptitude

- Reduced correction effort
- Reduced Lead Times
- Scaling Options
- Adaptability due to Modularity

Closed Mould
Preform
Resin
Resin
Trap
Vacuum
Press
Resin
Trap
Vacuum
Autoclave
Prepreg
Membrane
Open Mould
P
Closed
Mould

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Conclusion

Automation in composite production is needed to enable rate and constancy of quality.

Especially RTM offers many opportunities for automation.

Digital twins and augmented reality methods re-involve humans in automated processes.

*Human Centered Digitization* enables efficiency, traceability and quality control in composite manufacture.
Thank you for your attention!