Life Cycle Assessment for collaborative robot-assisted composite parts manufacturing using a work effort unit approach

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Business areas of the Fraunhofer ICT

Energy and environment

Chemistry and process engineering

Defense, safety and security, air and space travel

Automotive and transport technology
Clean Sky Programme – EU/H2020

Participants:

- 310 Industry Members
- 156 Universities
- 113 Research Centres
- 363 SMEs
- 30 Countries
- 113 Regions
+ 550 Grants

Goals:

- **CO₂**
  - CLEAN SKY 2008-2017: -20%
  - CLEAN SKY 2* 2014-2024: -30%
  - FLIGHTPATH 2050: -75%

- **NOₓ**
  - CLEAN SKY 2008-2017: -60%
  - CLEAN SKY 2* 2014-2024: -30%
  - FLIGHTPATH 2050: -90%

- **Noise**
  - CLEAN SKY 2008-2017: -50%
  - CLEAN SKY 2* 2014-2024: -75%
  - FLIGHTPATH 2050: -65%

*Refers to the impact of technology developed in Clean Sky 2 compared to state-of-the-art aircraft from 2014.
Clean Sky Approach & LCA Activity

- Performance of Life Cycle Assessment of new technologies and demonstrators
Main goals

• Evaluation of potential environmental benefits of the manufacturing of omega stringers in one of Airbus Defence using as main parameter the “Work effort unit”

• Automation of two key manufacturing steps of the reference technology:
  – lamination of main omega stringer structure through an Automated Fiber Placement (AFP) robotic process
  – cobotic pick-and-place process for Carbon Fiber Reinforced Polymer (CFRP) patches
State of the Art Vs. New Technology

Reference Technology

Hand lay up

(Source: Airbus Defence and Space)

CS2 Technology Innovation

Automation of omega stringers manufacturing for high curvature parts improving ergonomic, flexibility and productivity

(Source: Airbus Defence and Space)
Assisted Composite Manufacturing by Collaborative Robots

Components in scope

Omega stringers manufacturing for high curvature parts

New Technology

Assisted composite manufacturing by collaborative robots

(Source: Airbus Defence and Space)
Fan-cowl stringers or omega stringers are a key structural component providing stiffness for airframe parts
- being responsible for transferring the aerodynamic loads acting on the skin onto the frames
- for the aircraft service life since it is the access door to the aircraft engine

LCA – Definition

Environmental impact of products or service throughout their life cycle

Life cycle assessment framework

- Goal and scope definition
- Inventory analysis
- Impact assessment
- Interpretation

Direct applications:
- Product development and improvement
- Strategic planning
- Public policy making
- Marketing
- Other

Source: ISO 14040
LCA assumptions

- Work Effort Unit (WEU): mean energy consumption per productive hour in a typical Airbus Defence and Space factory
- Manufacturing power (energy resources) per productive area
- Energy demand:
  - 64% of electricity
  - 36% of natural gas

Energy consumption includes:
- CFRP Storage
- WEU – electricity and NG
- AFP robot
- Pick and place robot
- Hot forming (curing)
Input data - electricity demand

Omega stringer manufacturing by

Hand lay-up:

- WEU - electricity; 75%
- WEU - natural gas; 19%
- CFRP Storage; 7%

Collaborative robots:

- WEU - natural gas; 9%
- WEU - electricity; 36%
- CFRP Storage; 2%
- AFP robot; 7%
- Pick and place robot; 0%
- Hot forming energy; 47%

Lighting and climate control for the production area

With automation - total energy consumption by the factory in an 8-hour shift presents an increase of around 20%, but...
Results – with Work Effort Unit

• **2.7 hours** are needed to produce one unit of omega stringer by **hand lay-up**

• **0.7 hours** with **collaborative robots**

➢ **Lead time saving of 74%**

➢ **Total energy consumption per omega stringer produced shows a **decrease of 48%**
Extrapolation: energy saving with the automation of the process for one stringer unit to one twin-engine aircraft (A320neo) having an inboard and an outboard fan-cowl per engine with three stringers per fan-cowl, a total of 12 stringer in the aircraft, the total saving would be of 90 kgCO₂ eq and 3,000 MJ.
Conclusion

• Comparative LCAs (Reference Vs New):
  – key technical parameter is the reduction in lead time
  – robots consume additional electricity during the manufacturing process when compared to human workers
  – significantly shortens lead times (-74%)
  – resulting in lower energy consumption per manufactured unit for climate control and lighting in the factory

• LCA results, with the WEU approach, indicate that the new technology has the potential to improve the overall environmental performance of composite parts manufacturing

Increase of environmental awareness
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Thank you!