AEL Airborne – NDT challenges
Founded in 1995
200+ employees

Development, manufacturing and maintenance of composite structures and components

Facilities in the Netherlands, Spain and the UK

4 Business Lines:
• Aerospace
• Marine
• Services
• Composites Automation (Oil&Gas, spin-off 2014)
Experienced in automation – vision to reality
AEL Airborne
formerly Aviation Enterprises Ltd
Previous projects

1992-2005
Development of the “Magnum”
- Composite aircraft
- 100 HP, 160 knts cruising

2002
First tidal turbine blades for Seaflow

2005
Seagen MCT blades

2006
Quiet Revolution VAWT blades

2008
Deepgen 3 (TGL) 500kW

2012
Tocardo

2016
Confidential project

2016+
New tidal energy projects
Design & Engineering

- **Feasibility Studies**
  - E.g. Viability of conversion of metallic structure to composite, through ensuring understanding of customer need, providing scenarios/options for customer choice.

- **Conceptual design**
  - E.g. Using provided geometry, method of dividing product into smaller productionisable components for easy assembly & assembly methodology.

- **Laminate/stress engineering using hand calculations, in-house tools and FEM**
  - E.g. Design study for tidal turbine blade including root connection, fatigue and approval.

- **Certification liaison**
  - E.g. DNV-GL approval of tidal turbine blade

- **Design-For-Manufacture**
  - E.g. Re-design of composite bridge module to reduce cost of manufacture, showing evolution of cost with volume (learning curve); options for tooling investment vs piece price; and automation options (investment vs piece price)
Material Characterisation

- Extensive knowledge of long term service in submerged seawater environments through characterised material properties of saturated laminates.
  - Glass/epoxy infused
  - Carbon/epoxy prepreg
  - Glass/epoxy prepreg

- Developing experience in degradation of mechanical properties through exposure to chemically aggressive environments.

- Combination of in-house testing and use of third party laboratories to generate material properties suitable for use by certification bodies.
Prototyping and Production

- **Considerable experience building „first off“ parts**
  - Design and contracting of plug manufacture
  - Female moulds including backing frame made in-house
  - Jigs/fixtures made in-house

- **Scale-up and ongoing production**
  - Production tooling
  - Application of mechanisation to reduce labour content
  - 3D scanning; use of DSC; use of FTIR; use of NDT - for QA/QC

- **Understanding of economies of scale**
  - Tooling options – „soft“ vs „hard“ – investment vs return
  - Mechanisation of individual processes to reduce cost
  - Payback calculations and learning curve rates for volume vs cost.
  - Options for full automation (cutting; pick and place; ply sorting; ply deposition etc)
NDT challenges
Tidal turbine blades

- Designed using saturated material properties
- Typically fatigue-driven designs (20 year life)
- Generally a trade-off between hydrodynamic performance and structural configuration – often means solid, or very thick laminates
- Typically use adhesive bonding (composite-composite and metal-composite)
- Often use carbon, but also glass-only designs.
- Hostile environment and difficult in-service monitoring
- Cost of installation and retrieval is very high
- Prototypes need to work
- Manufacturers want certification
- Little economy of scale yet
Production test questions

- Does the laminate have the required strength?

- Does the laminate have the properties assumed in the design?
  - Fibre wet-out
  - Void Content
  - Fibre alignment
  - Fibre / ply wrinkling
  - Correct reinforcement materials, stacking sequence, orientation
  - Correct matrix material
  - Degree of cure

- Can we prove it to the satisfaction of a client without composites experience?
In Service test questions

- Is the laminate still strong enough?

- Is the laminate still resistant to the environment?
  - Fatigue damage accumulation (cracking and delamination)
  - Material strength reduction.
    - Matrix strength reduction
    - Fibre / matrix interface degradation (sizing)
    - Fibre corrosion

- If it breaks, what caused it.....
Our Challenges

- **General**
  - Heterogenous laminates
  - Not “Aerospace-grade” laminates – some voids are “ok”
  - Thick laminates (100mm-200mm)
  - Large products (5-25m long)
  - Verification of whole part, not just the local area tested.
  - Needs to be quick, cheap, reliable, and credible to non-composites people.

- **In-service specific**
  - In-situ (underwater)
  - In-situ (out of the water, but not disassembled)
  - Coated, potentially with elastomeric material.
Challenges

- Infused glass/epoxy
- Difficult ultrasound penetration
- 110mm thick laminate
- Adhesive joint at the other side of the laminate
- Cost effective, quick and easy

“Poor laminate”

“Good laminate”

“average laminate”
Summary

We want/need to be able to:

- Differentiate between intentional “non-homogeneity” (e.g. layers, lamination features), and non-intentional (dry spots, scissors....)
- Determine the location of intentional defects in plan and through-thickness
- Determine the size and identify the type of defect.
- Achieve this on industrial structures that do not allow for multi-million investments.
- Needs to be in-process to allow production flow, and prevent defects/scrap from having value-added.
- Prove to customer that the final product is “good”
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