NDT Workshop – Manufacturers perspective

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Public

13 Feb. 2019

Agenda

Contents:

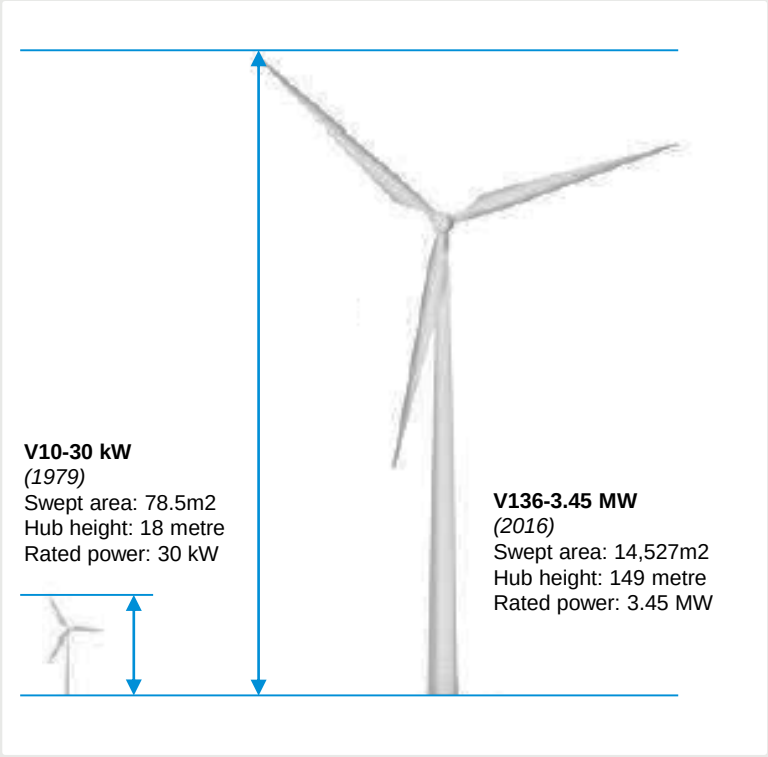
Introduction

Setting the picture

Vestas has been a pioneer in wind energy solutions since 1979. In late 2018, a new milestone was reached:

100GW of installed windpower.

Since the inaugural installation of a V10-30 kW turbine in Denmark in 1979, Vestas has installed over 67,000 turbines in around 80 countries across six continents.



Introduction

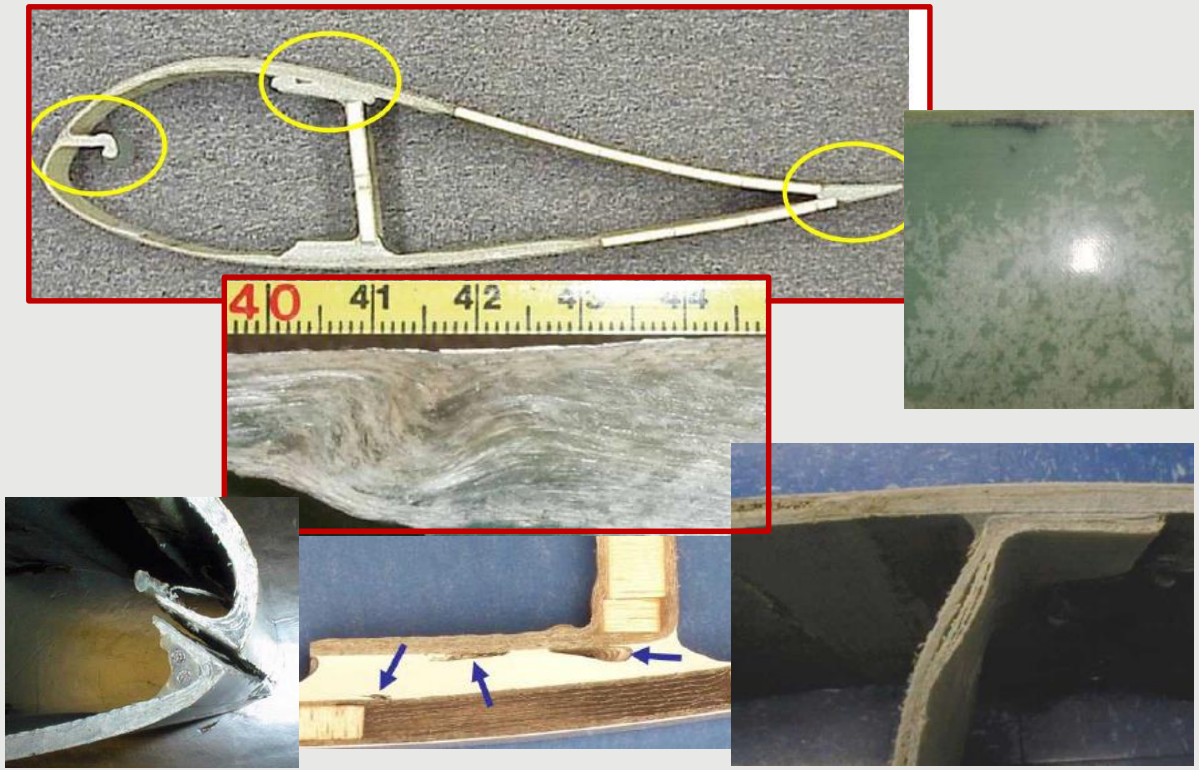
Market situation in Wind industry

- *LCOE* → *Rotor diam.* → *Load*
- *Blade production volume increased*
- *Decision against full automation of blade production.*
- *Quality control more important than ever*

Typical Flaws

Quality issues

- Disbonds, Kissing bonds
- Air inclusion, snow flaking
- Wrinkles, ply waviness
- Delaminations
- etc

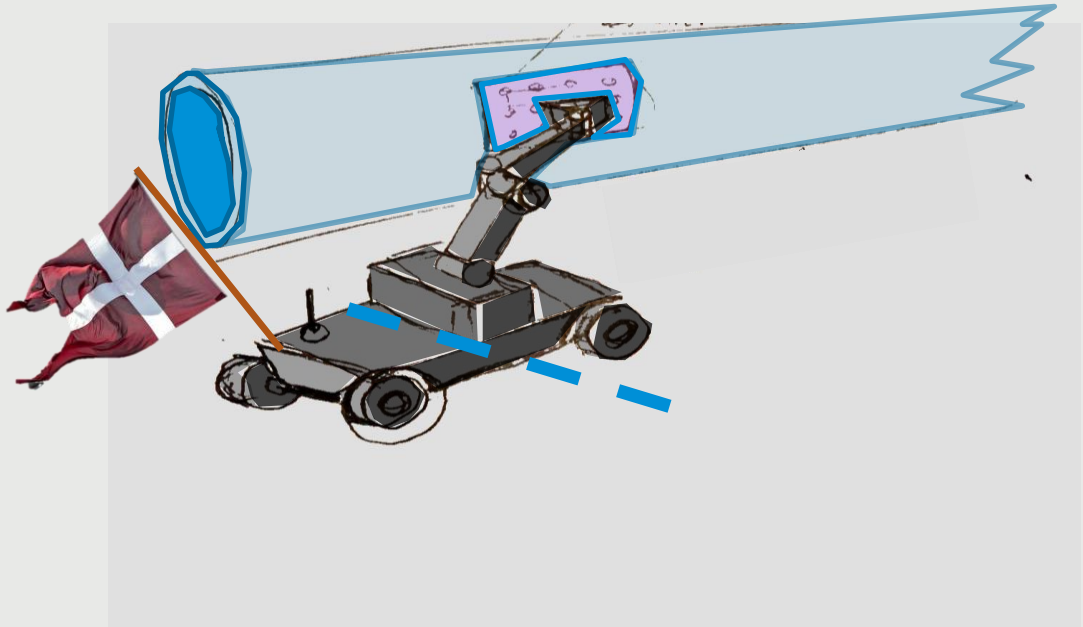


Pictures courtesy of SANDIA National Laboratories

NDT Processes

Bond issues - NDT Process

- Production site: UT scanning with an array of low frequency transducers
- Scan time ~5hrs
- Evaluation done centralized at remote office.



NDT Challenges

Bond issues – evaluation challenges

Attenuation of signal

- Voids
- Material composition
- Coupling

Resolution of C-scan

- Wavelength

Interpretation of C-scan

- High turn over of people
- Ambiguities

NDT Challenges

Bond issues – Development focus

Attenuation of signal

- Voids
- Material composition
- Coupling

→ Efficient coupling to non-plane, non-smooth surfaces
Improved electronics/ transducer design

Resolution of C-scan

- Wavelength

→ Improve processing, eg. TFM for composite

Interpretation of C-scan

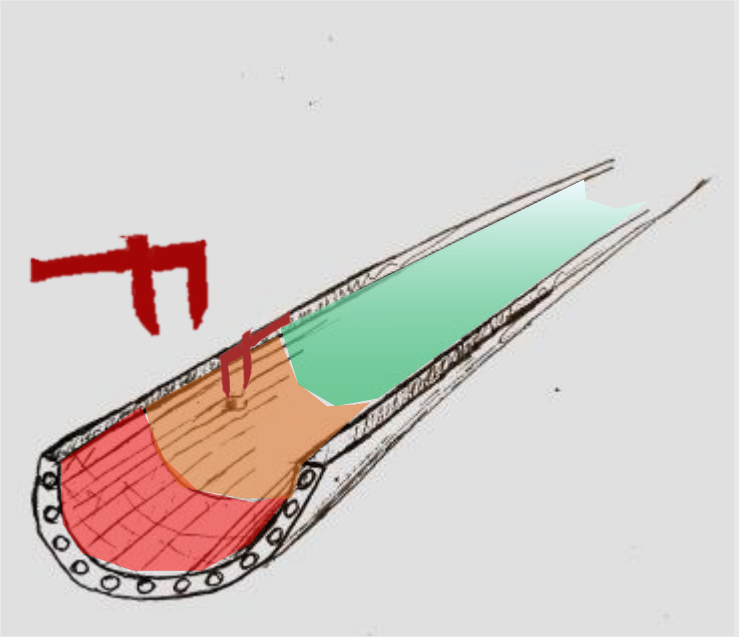
- High turn over of people
- Ambiguities

→ Artificial Intelligence, automatic processing

NDT Challenges

Wrinkle issues- evaluation challenges

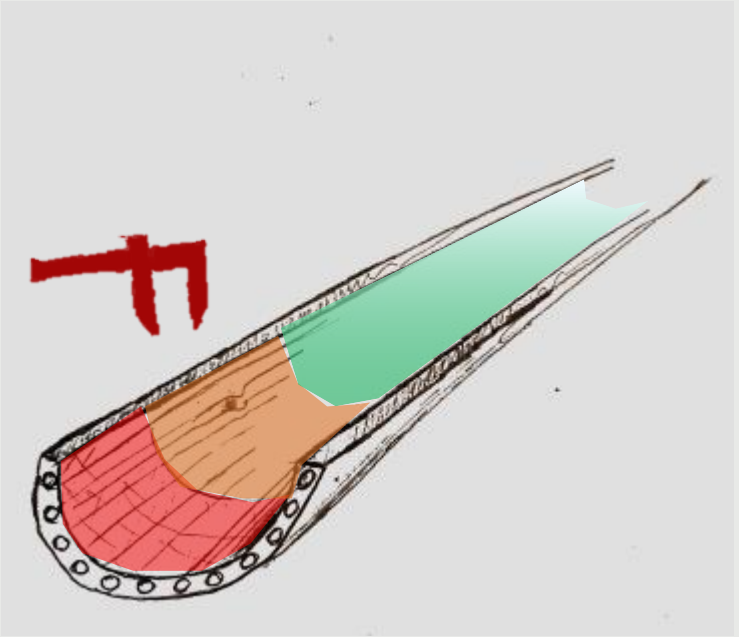
- Manuell investigation for ‘bumps’
- Measuring size of ‘bump’
- Comparing to zonal allowables



NDT Challenges

Wrinkle issues- evaluation challenges

- Surface bump not telling what's below
  - **False negative:** compromising blades integrity
  - **False positive:** Unnecessary repair costs
- Wrinkle invisible from surface
  - Operator not detecting wrinkle



NDT Challenges

Wrinkle issues- Development focus

- Surface bump not telling what's below
  - **False negative:** compromising blades integrity
  - **False positive:** Unnecessary repair costs

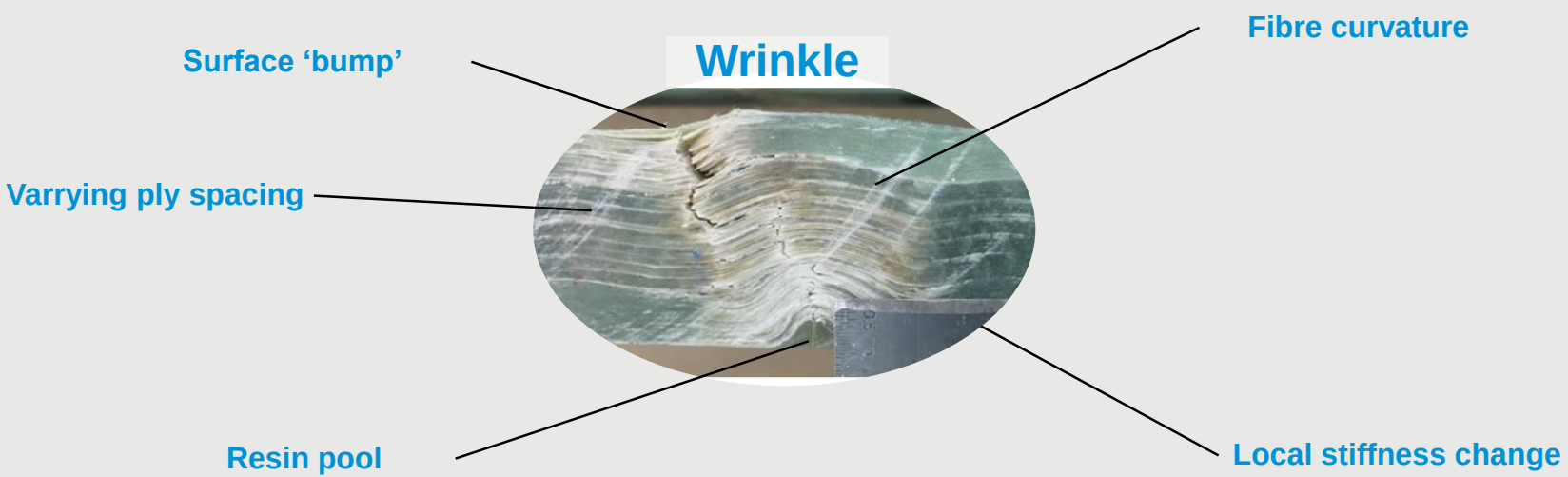
→ Evaluating ply curvature in laminate

- Wrinkle invisible from surface
  - Operator not detecting wrinkle

→ Automated screening

Case study - Evaluating ply curvature in laminate

Wrinkle features



Case study - Evaluating ply curvature in laminate

Wrinkle features

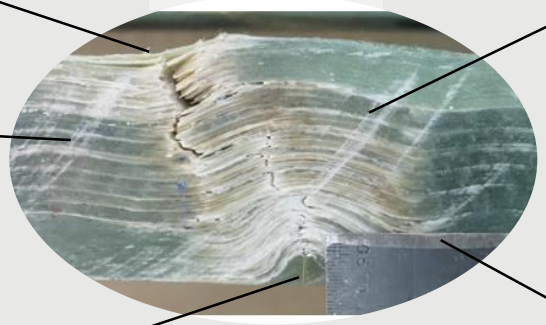
Detectability

Surface ‘bump’

Varrying ply spacing

Resin pool

Wrinkle



Fibre curvature

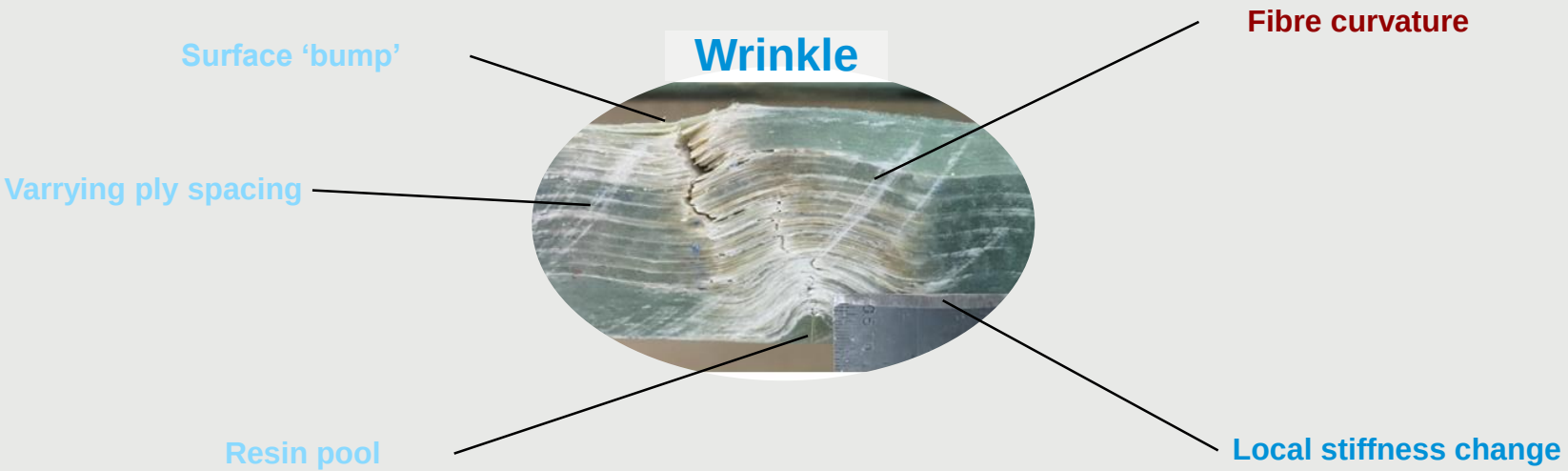
Local stiffness change

Vestas

Case study - Evaluating ply curvature in laminate

Wrinkle features

Strength effect

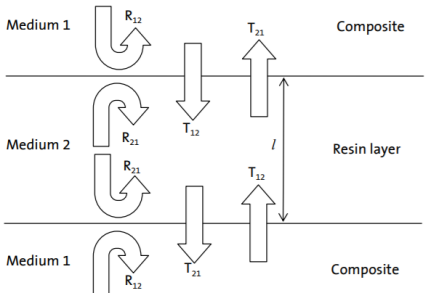


Vestas

Case study - Evaluating ply curvature in laminate

University of Bristol – Prof. R.A. Smith and group work

- Ultrasound inspection
- Laminate periodic structure
- Tuning in resonant frequency
- Phase information stores ply mapping
- Successful in Aerospace
- Vestas collaborating with Bristol to adapt to Windgrade composite



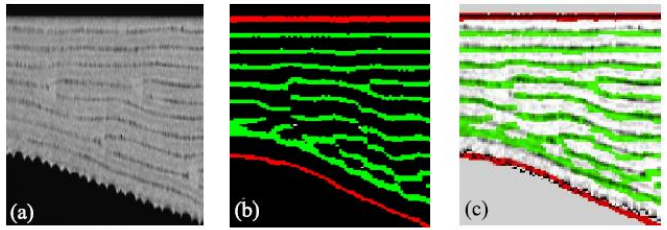


Fig. 9. Wedge specimen containing ply-drops, made from 0.189-mm plies and incorporating 0.04-mm resin layers. (a) X-ray CT slice. (b) Ultrasound-derived front-surface (red), back-surface (red), and resin-layer (green) locations (c) overlaid on X-ray CT data. The ultrasound scan used a 38-mm spherical-focus 7.5-MHz probe.

Illustrations courtesy of R.A. Smith

Thank you for your attention

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