NDT with Air-coupled Ultrasound – Quality Control and Competitive Advantage for Suppliers

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Outline

Air-Coupled-Ultrasonic Testing (ACUT)
• Through-transmission measurement
• ACUT of a CFRP sample
• ACUT of a foam laminate sample
• ACUT of a honeycomb sample

Inspection Task

Inspection Setup

Result of the Feasibility Study

Measurement Results with the Customer Specific Setup

Business Case Considerations

Conclusion
State of the art
- Missing adhesive leads to additional interfaces
- Intensity losses indicate vacancies

Through-Transmission Measurement

-40 dB
-80 dB
-160 dB

Incoming sound wave
transmitted sound wave
CFRP Reference Specimen

- Standard reference block (aviation industry)
- Multiaxial CFRP
- Steps: 10 – 8.8 – 6.6 – 4.4 – 2.2 mm
- 300 kHz C-Scan
- Through transmission measurement

300 kHz C-Scan
CFRP Sandwich with Foam Core

- **Electronics:** SONOAIR
- **Transducer:** CF050 & CF075
- **Specimen:** CFRP with 3” foam-core
- **Flaws:** Washers as artificial flaws
Impact damage detection with ACUT above:
- CF200 Transducer
- impact damage visible as amplitude reduction

right:
- CF400 Transducer
- Honeycomb structure visible
- Impact damage can only be detected in the C-Scan image

Test parts provided by ThermHex Waben GmbH, thanks to Mr. Pflug
Sheet Molding Compound
- GFRP manufacturing method
- Multiple layers of glass fiber
- Up to 6” thick

Common Flaws
- Delamination
- Insufficient infiltration

Specimen
- Trough transmission measurement
- 14 x 7 x 0.5 ft actual plate size
- 15 x 15 x 2” for application development
Inspection Setup

Setup
- 75 kHz
- 4 mm x 4 mm scan stepping
- 4 inches/s
- No filters
- No average
- No post-processing
Result of the Feasibility Study

**Intensity**

**Time-of-flight**
Result of the Feasibility Study

Intensity
Result of the Feasibility Study
Result of the Feasibility Study
Result of the Feasibility Study
Measurement Results with a Customer Specific Setup

- Production of a flawless sample
- Sight scattering in amplitude and time of flight due to density
- Significant interference pattern on the edges
Measurement Results with a Customer Specific Setup

- Reference filter
- Automatic measurement of flawed area in %
Measurement Results with a Customer Specific Setup

Direct feedback via Profinet to industrial standard PLC
Industrial Size Measurement System

- PLC controlled scanning system
- Fully integrated in production process

- Channel: 4
- Scan area: 14 x 7 ft
- Stepping: 0.2 x 0.2 inches
- Scan speed: 20 inches/s

- Flawed area is assessed and measured
- Feedback loop to subsequent CNC-machinery
- Automatic documentation of test reports for quality certificates
Business Case Considerations

SONOAIR Machine Invest: ~ USD 250,000
- Inline system
- No wearing parts in testing hardware
- Automated detection of flawed areas
- Minimal maintenance costs

Machine utilization: 144h per month
Operating life: 10 years
Interest: 5%
Area costs for 15m²: USD 60 per month
Electricity consumption: max 2kW

Capital Costs: 2775$ per month
Calculative interest: 535$ per month
Maintenance costs: 215$ per month
Area Costs: 60$ per month
Energy Costs: 18$ per month
0.2$ per hour

→ Machine Costs ~ USD 26/h
Business Case Considerations

- Business opportunities
  - NDT Tool for quality und process improvement
  - Reduction in set-up time

- Reduction of rejected parts forwarded to mechanical processing
  - No flawed half-finished products in further processing
  - Time cost per hour CNC milling: ~ USD 100

- Attachment of scan results as quality certificate
  - Competitive advantage
  - Compelling reason for 10% price increase

- Possibility to offer different quality grades
  - Earning money on product that would otherwise have cost money due to complaints/returns
  - Saving in recycling and waste costs
Conclusion

- GFRP SMC can be tested in through transmission with ACUT
- Small flaws affect the received amplitude
- Detection and localization of single air bubbles is not possible
- Large stepping is sufficient even for small flaws

- Integration in existing industry production system
- PLC – Feedback for subsequent production processes
- Automatic quality certification as competitive advantage
Thank you for your attention!