The Future of Quality Control
Intelligent and Autonomous

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“The bitterness of poor quality remains long after the sweetness of low price is forgotten.”

Ben Franklin
Evolution of Quality Control

Past:
- Does it look right?
- Six Sigma

Present:
- Lean manufacturing
- Total Quality Management

Future:
- Steer the ship
- Self-correct
Enablers of Industry 4.0
Cost

• Which Cost?
  o Money?
    - Facilities and Equipment
    - Training
    - Personnel
    - Maintenance
    - TCO
  o Time?
    - Development
    - To market
    - Down time
  o Speed?
    - Of manufacturing
    - Of learning
    - Of delivery

• Cost of Failure???

• $50BB of market cap lost in 4 months
Technological Sophistication

• The counterpart of COST

• HOW?
  o System Design
  o Image Processing
  o Automatic Defect Recognition
System Design

1. Load Part
2. Part ID
3. Barcoding
4. Load Profile
5. Inspect Part
6. Characterize
7. Unload Part
Image Processing
Defect found in ADE filtered Image.
Put It All Together...
OK, but What Else?

Porosity Analysis

Nominal-Actual Comparison

Wall Thickness

Oxide Detection
Example 1: Carbon Fiber Composite Material

Porosity analysis performed on CT volumetric data to capture voids

The part is fabricated by ArrisComposites at University of California, Berkeley.
Wall Thickness
Oxide Detection

160 kV, 100 μA, 1 mm Cu filtration
Achieved voxel resolution 7.4 μm

Figure 4 Radial slices to show surface determination at three different layers: (a) alloy only, (b) alloy and coating, and (c) with the corrosion layer.

Figure 3 Vertical slices to show surface determination at three different layers: (a) alloy only, (b) alloy and coating, and (c) with the corrosion layer.

The part is fabricated by Material Science and Engineering School, UC Irvine.
Wood/Log Characterization

CT Log Inspection

X-ray CT data is used to optimize sawing to achieve maximum yield

X-ray Generator operating at 225KV, 3KW at 37G
Quality Feedback Loop
Tomorrow

**First Article Inspection:**
- Compare As-Built to Engineering
- Simulation Tests
- VR / AR

**Initial Batch:**
- Ensure ADR working
- Simulation Tests
- Monitor variables via IIOT / Big Data

**Production Mode:**
- Monitor any deviations in part quality and variables
- Halt when deviation out-of-bounds

**Make Adjustments:**
- Adjust process based on variables
- Big Data / Deep Learning

**Flow Diagram:**
- Tomorrow
- First Article Inspection
- Initial Batch
- Production Mode
- Make Adjustments
Not Science Fiction

• Currently working in consortium for castings with:

  - Pratt & Whitney
  - ATEK Metal Technologies
  - MAGMA
  - PALMERFOUNDRY
  - MERCURY
  - WPI

• Other industries include:
  • Electronics, Consumer Products, Munitions, Power
One More Thing...
Thank You

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