Defect Detection & Prevention In Cast Turbine Wheels

A novel approach for improving turbine wheel quality using eddy current inspection

Jack Rose
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Turbocharging

*Increased POWER and EFFICIENCY*

*Speeds exceed 200 000 rpm*

*Greater than 700°C*
Turbine wheel basics

1. Wax Pattern making
2. Tree Assembly
3. Immersion in prime coat
4. Melt out the wax pattern
5. Prime coat
6. Back up shell
7. Application of back-up shell
Turbine wheel basics
New Cast Turbine Wheel

Failed Turbine Wheel
Casting defect

Blade root

Turbine blade fracture surface

1mm

2mm

0.25mm
Area of Interest

86mm
How can we detect these defects?
Solution?
Manufacture of bespoke flexible array eddy current probe by Eddyfi
**Probe setup**

- The probe contains 15 x 2.2mm diameter coils
- The coils are mounted onto a flexible wear resistant plastic
- The coils are organised in transmit and receive configuration with 8 coils on row 1 and 7 coils set behind in row 2.
- An additively manufactured plastic probe guide fit between the wheel blades to guide the probe along its scanning path.
- The coils are in a pancake form each with ferrite cores.

<table>
<thead>
<tr>
<th>Scan Parameters</th>
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<tbody>
<tr>
<td>Y –Axis scan speed</td>
<td>10mm/s</td>
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<tr>
<td>Frequency 1</td>
<td>500kHz</td>
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<tr>
<td>Frequency 2</td>
<td>300kHz</td>
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Probes capability

Slot A = Slot B

All dimensions in mm
Artificial slot on machined surface
Sub-surface artificial holes

Scanning surface and direction

Sub-Surface Dimensions

0.1mm  0.25mm  0.5mm  0.75mm  1mm
Real defect on real component

Turbine blade

The animation is just a representation
Real defect on real component

500 kHz scan

Vpp = 0.56V

35mm

300 kHz scan

Vpp = 0.31V
Defect detected by 3DXRCT and analysed at the University of Manchester (MXIF) highlighted artificially in blue.
Prevention

Supplier Collaboration

1. **Identify** process that introduces defects into casting
2. **Consider** methods for reducing effect of this process
3. **Monitor** defect count on casting optimisation trials
4. Perform durability tests to **validate** improvements by eddy current inspection
Baseline Results

Defect Blade Distribution

Blade Number

Blades scanned = 576

Voltage Distribution

Voltage

Phase Angle Distribution

Phase Angle

Public Classification
Further work

Currently testing 9 options for quality improvements that examine:

- Third tier supplier quality (alloy bar quality)
- Casting parameters modifications
- Additional steps to manufacturing that could improve quality