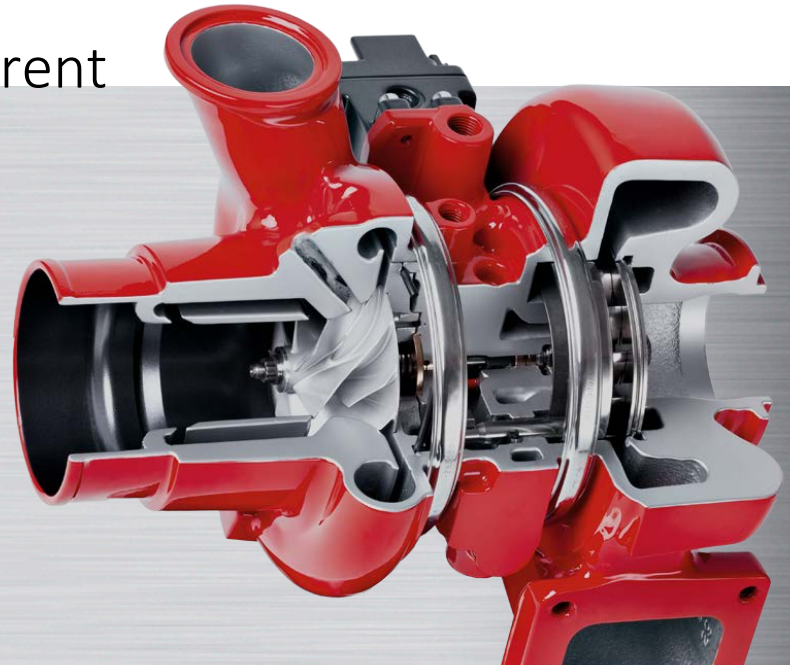
Defect Detection & Prevention In Cast Turbine Wheels

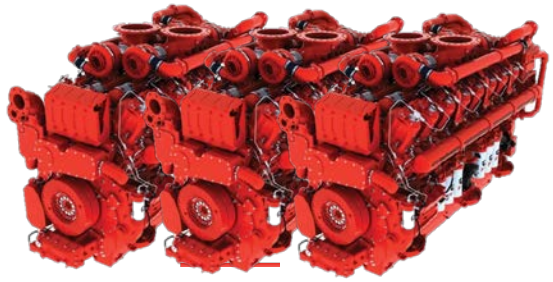
A novel approach for improving turbine wheel quality using eddy current inspection



Jack Rose

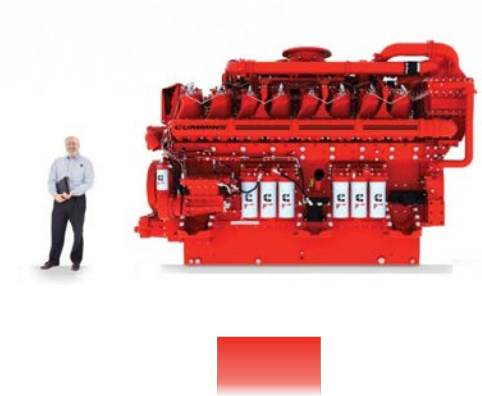
September 2015

Cummins Turbo Technologies



Cost of Cast Component

Cost of Component



Cost of System

Cost of Customer Disatisfaction

Turbocharging

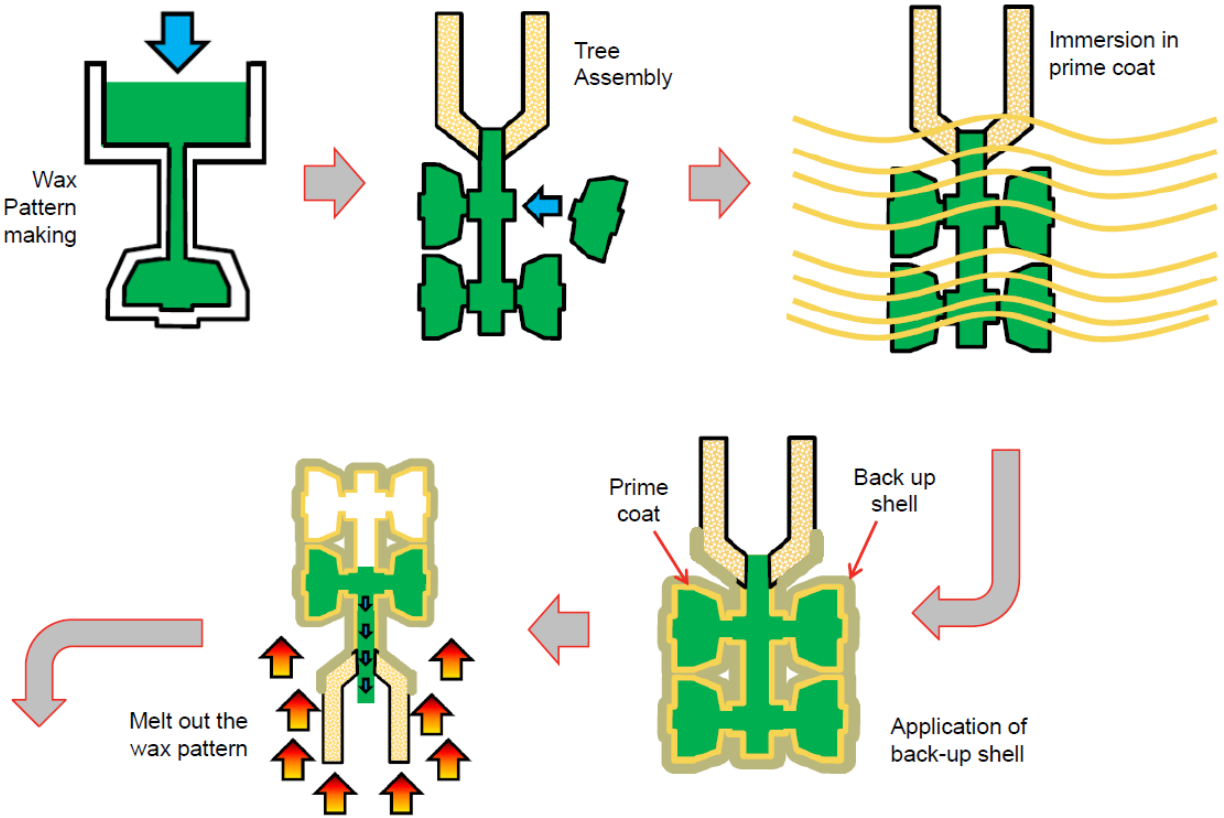
Increased POWER and EFFICIENCY

Speeds exceed 200 000 rpm

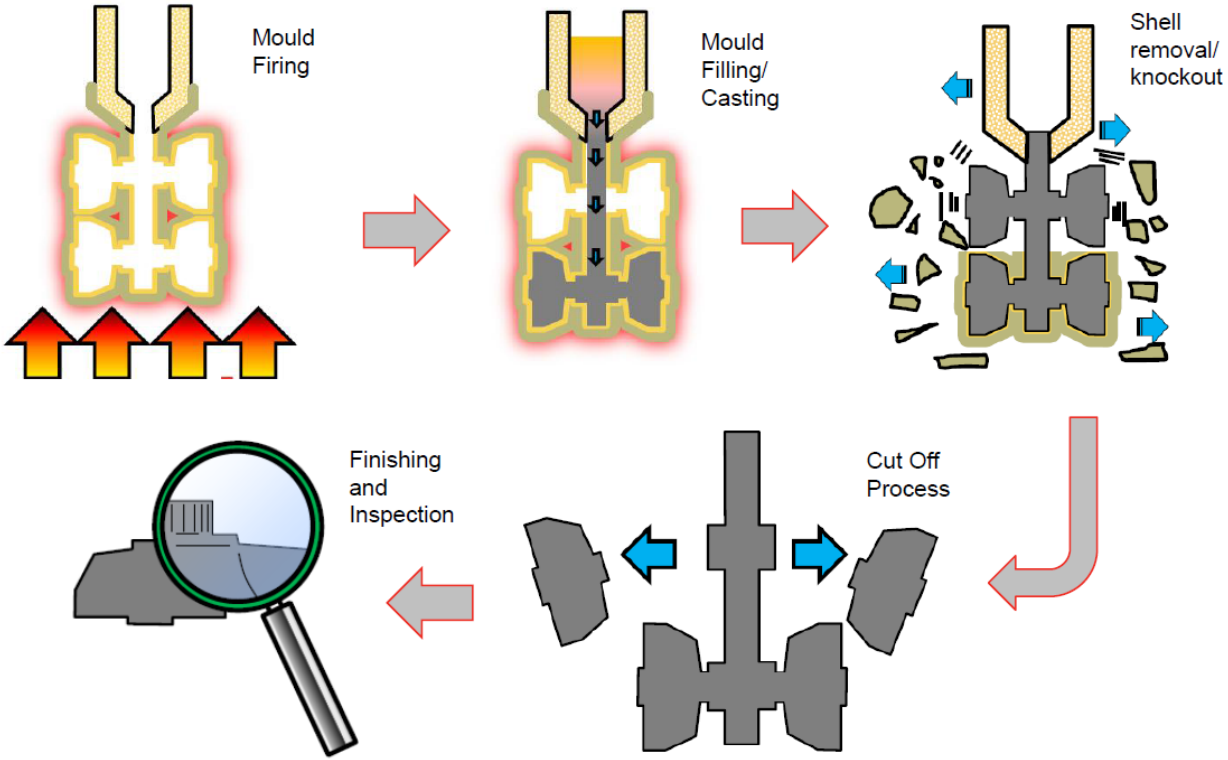
Greater than 700ºC

HOLSET®
TURBOCHARGERS

Turbine wheel basics



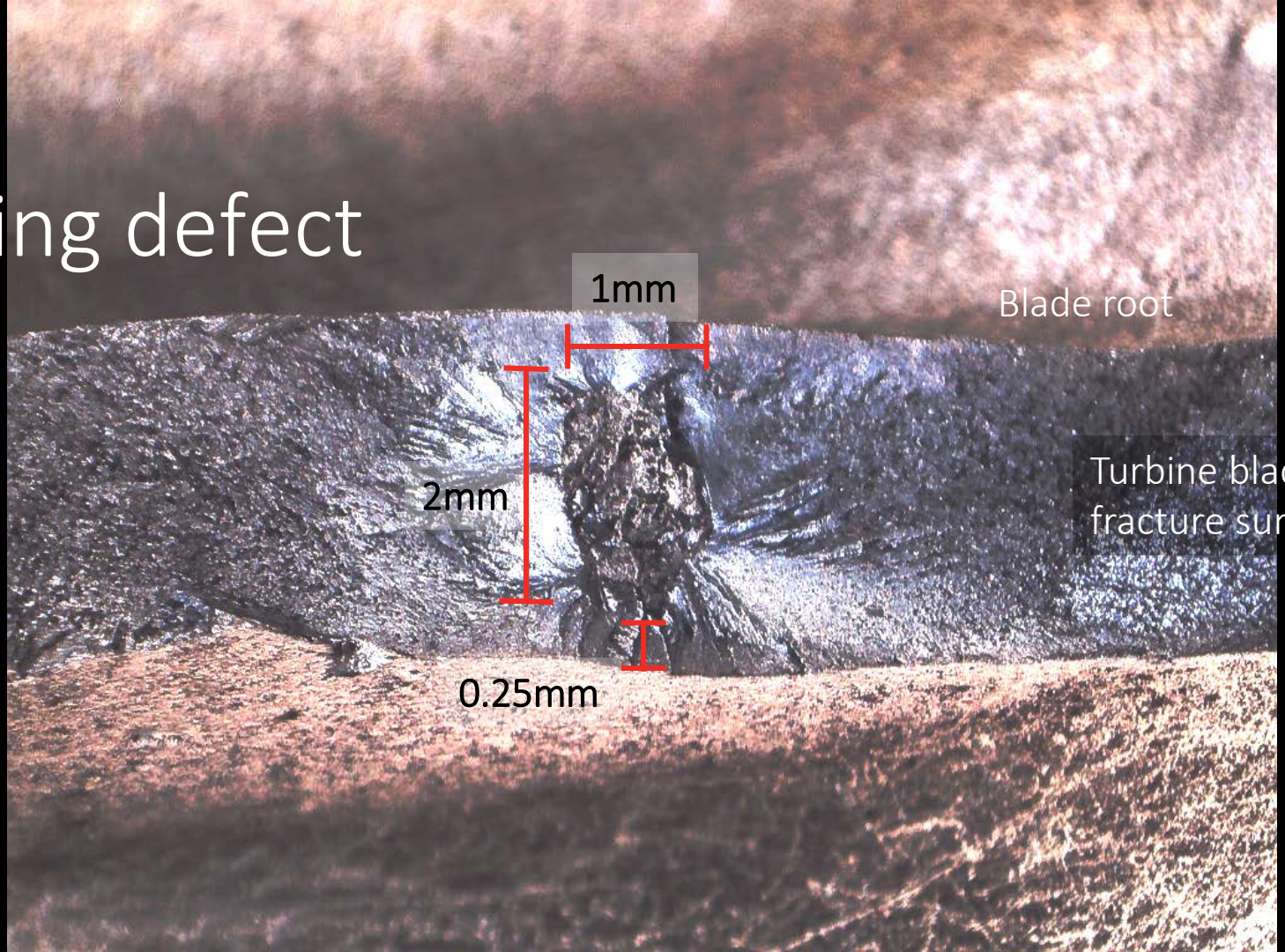
Turbine wheel basics



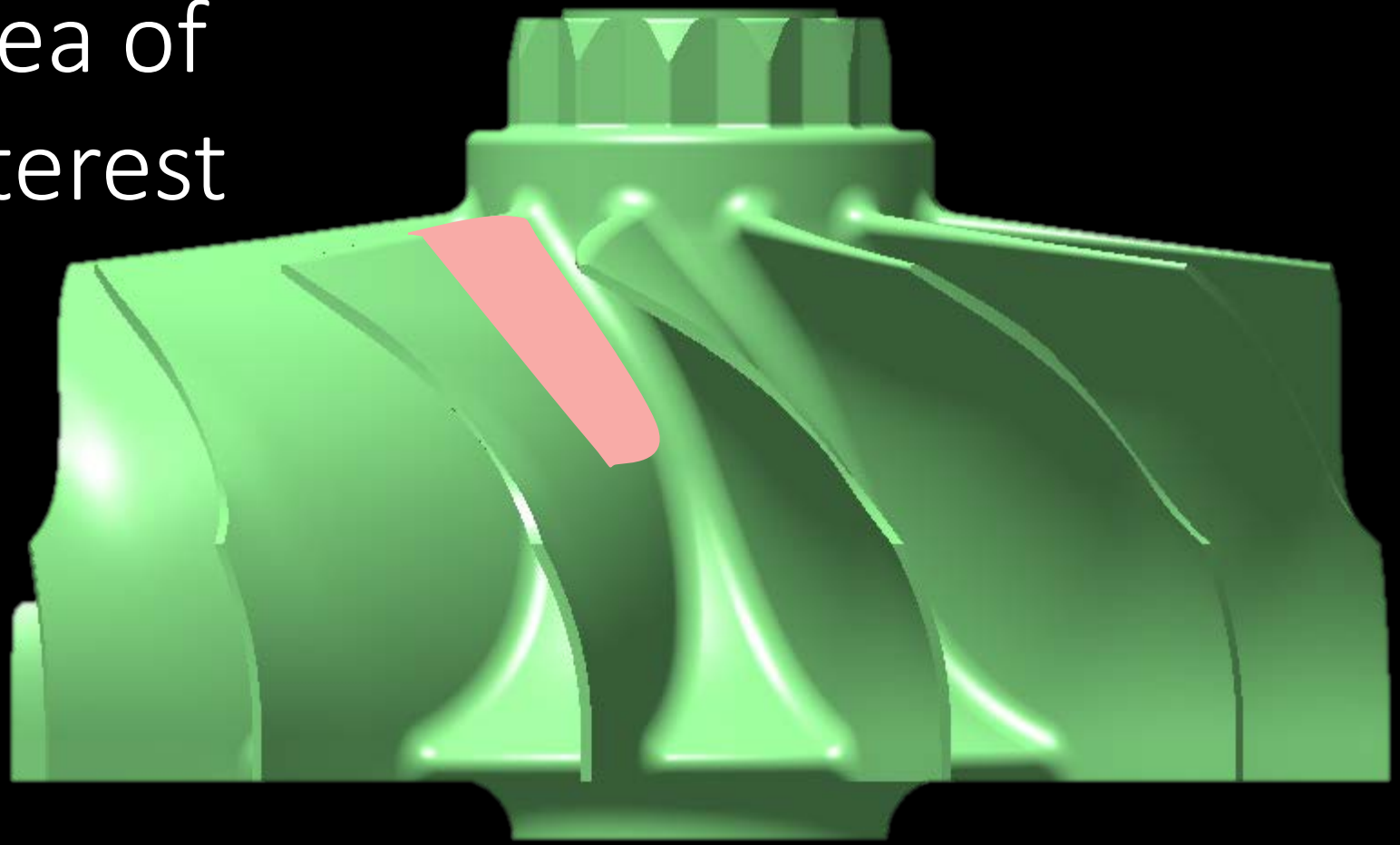
New Cast Turbine Wheel

Failed Turbine Wheel

Casting defect



Area of Interest



86mm

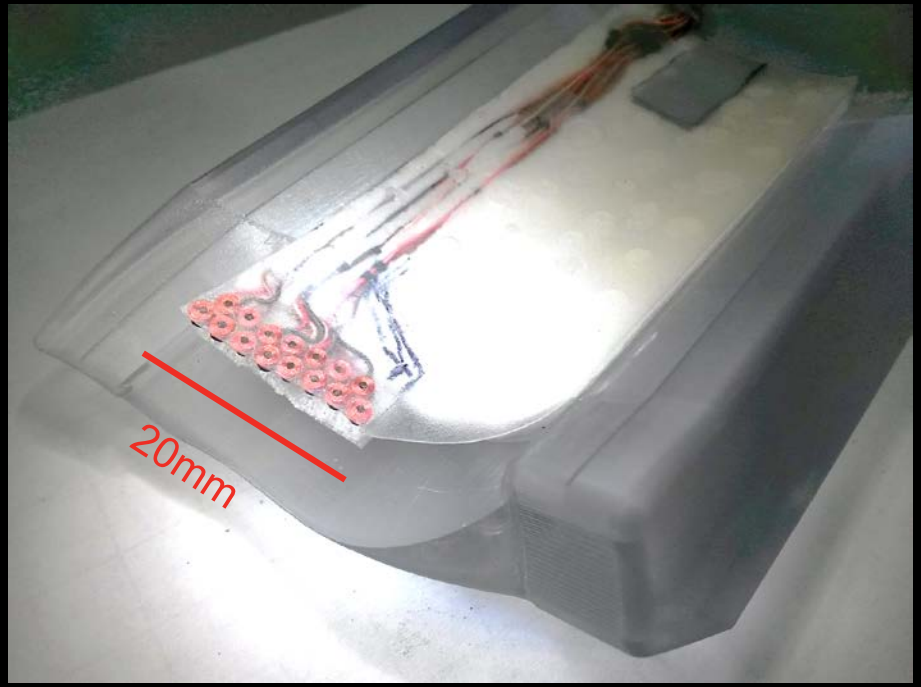
How can we detect these defects?

Solution?

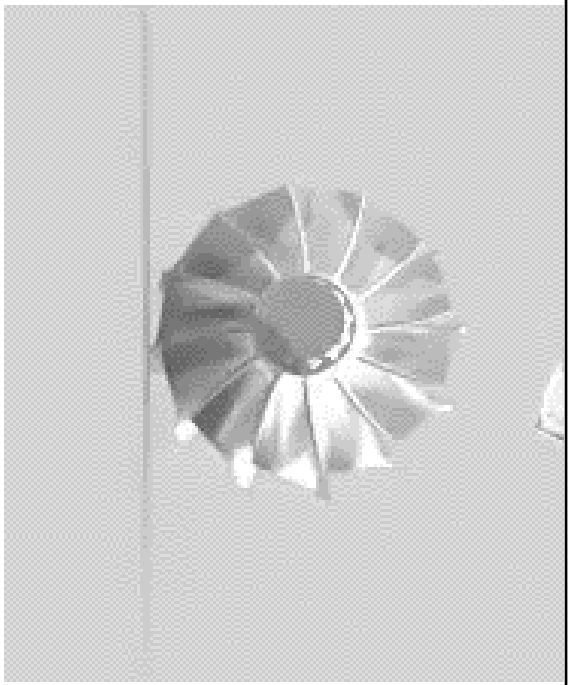
Manufacture of bespoke flexible array eddy current probe by Eddyfi

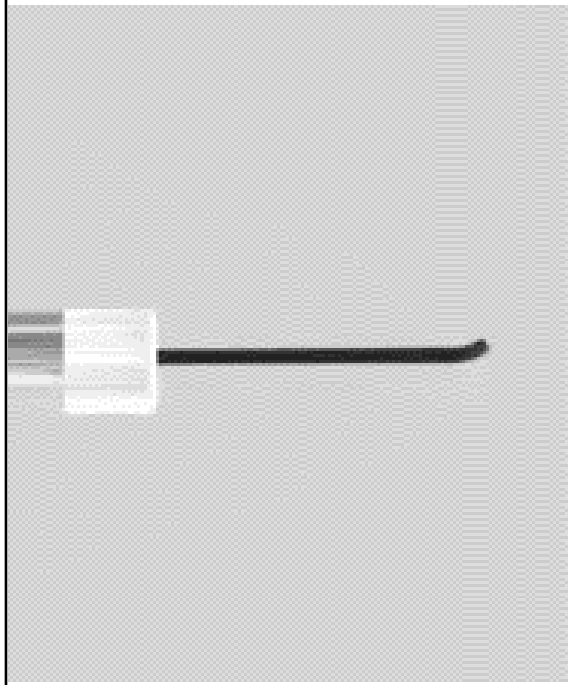
Probe setup

- 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.

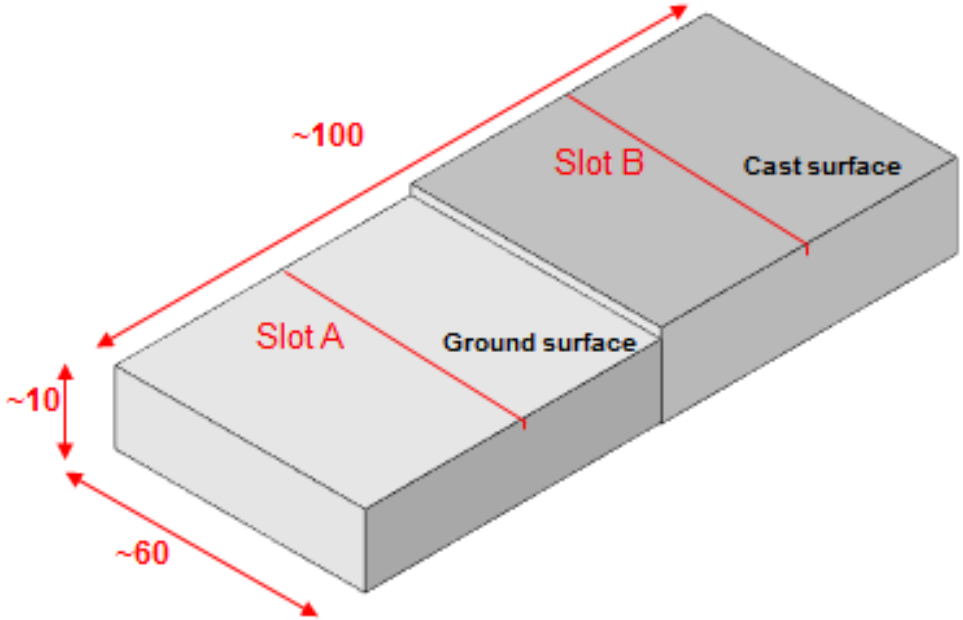


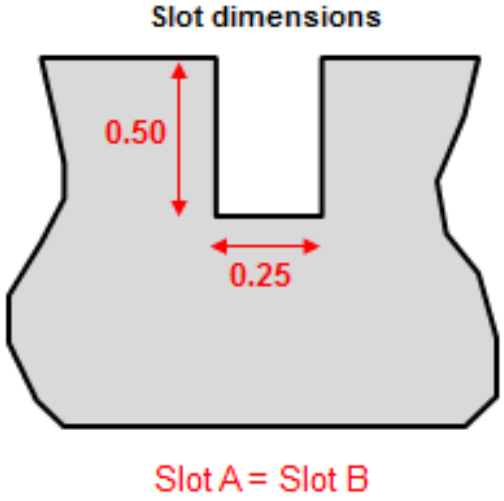
Scan Parameters	
Y –Axis scan speed	10mm/s
Frequency 1	500kHz
Frequency 2	300kHz





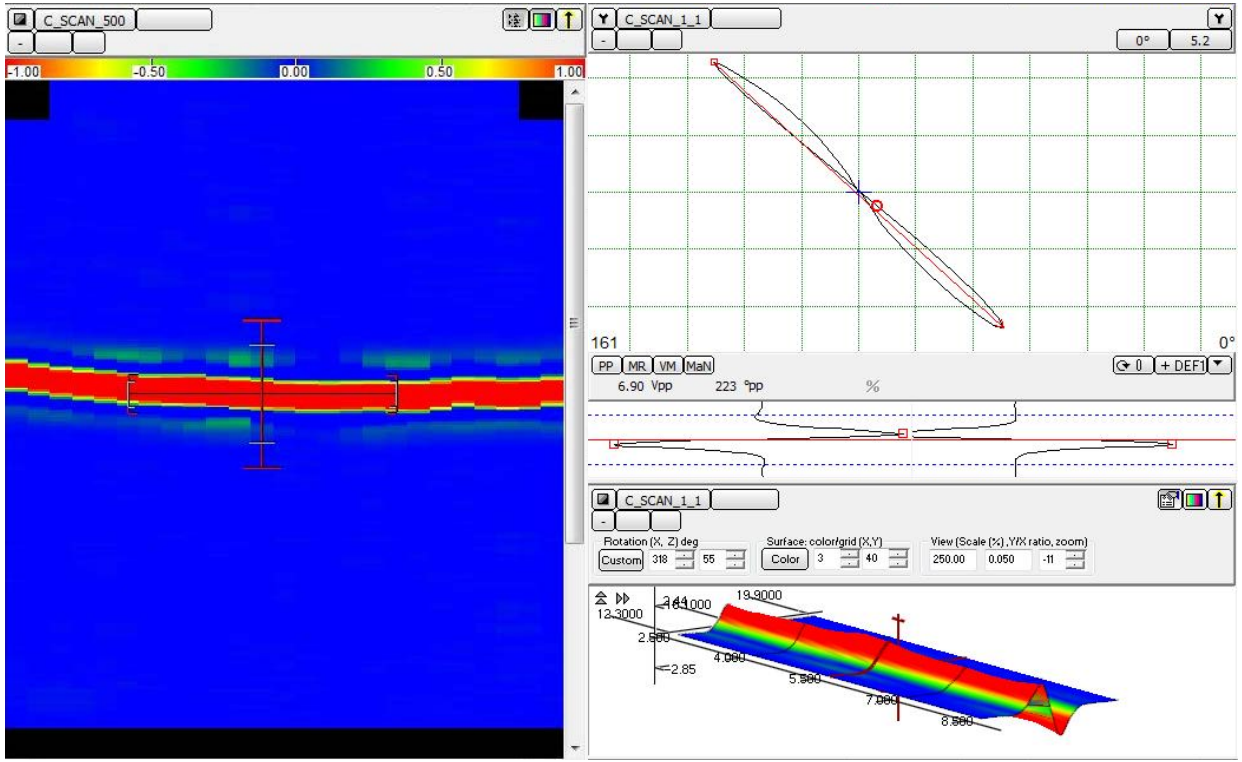
Probe capability



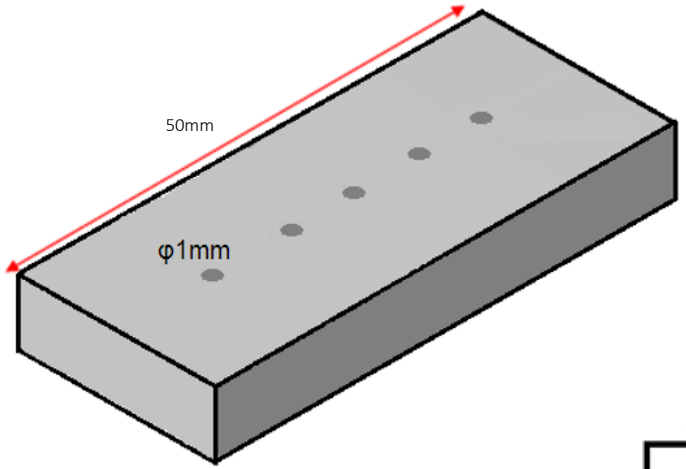


All dimensions in mm

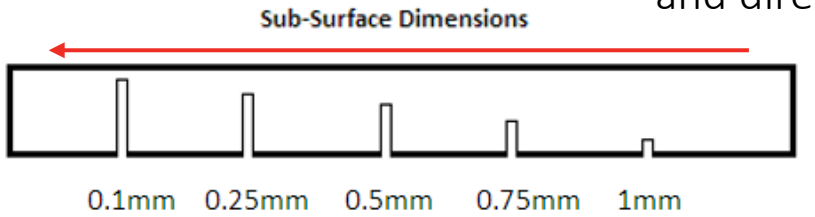
Artificial slot on machined surface

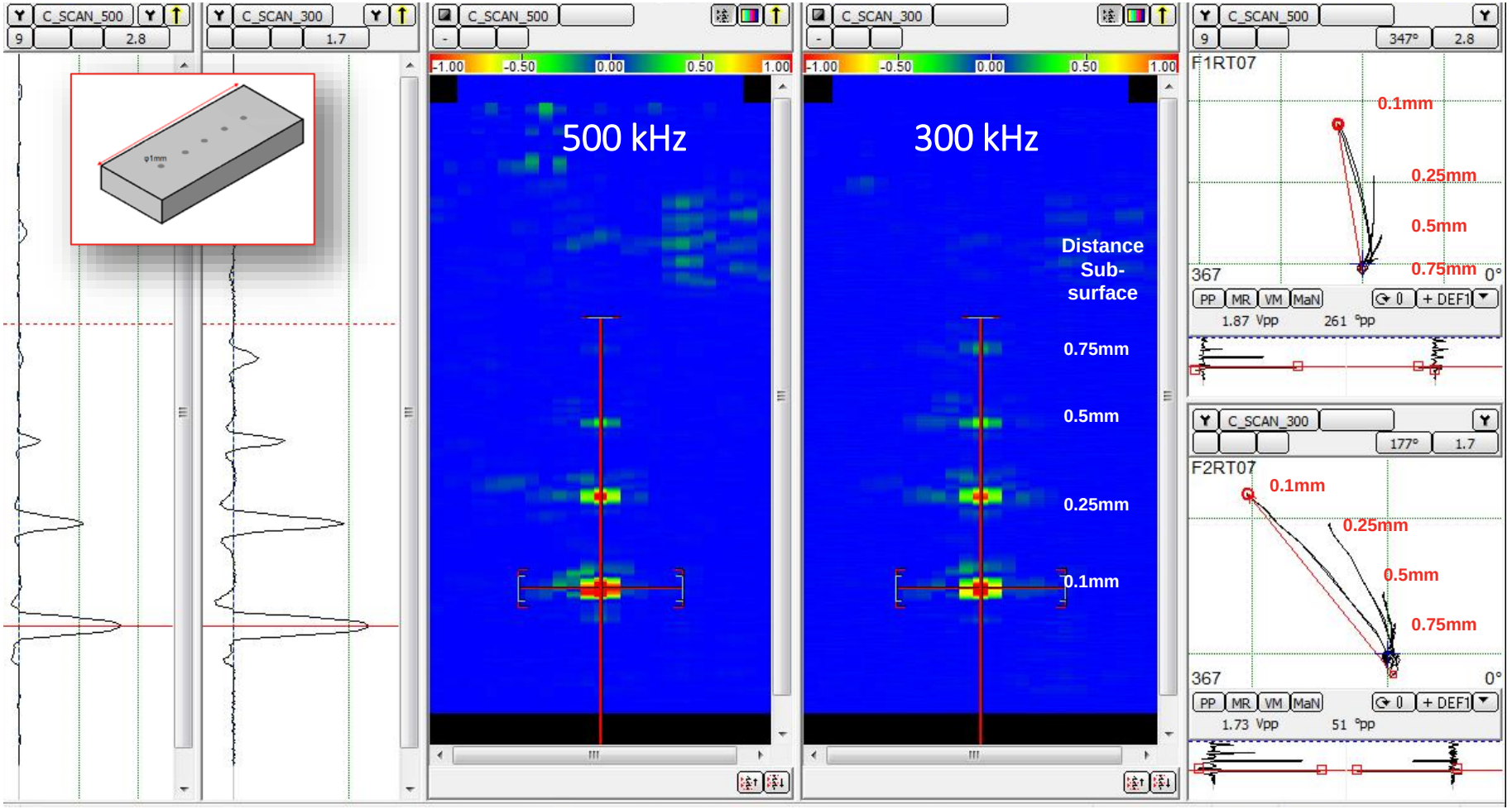


Sub-surface artificial holes

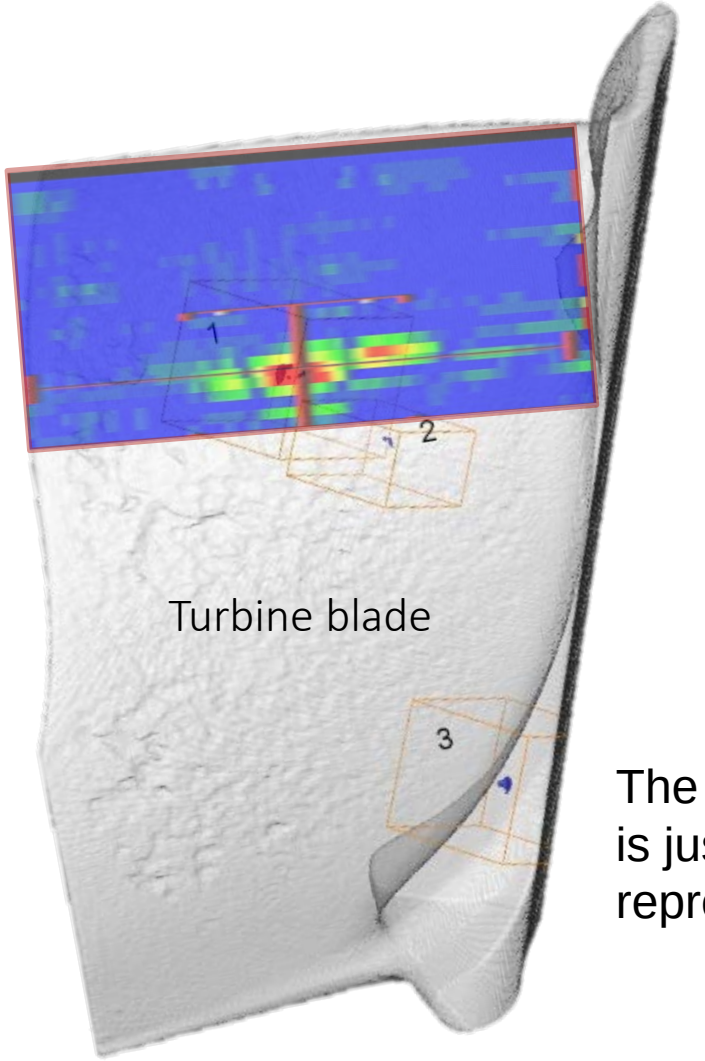


Scanning surface and direction





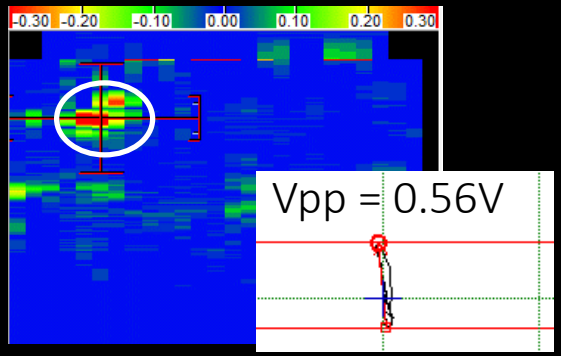
Real defect on real component



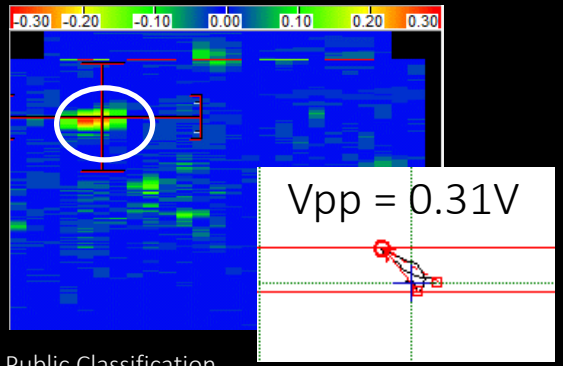
The animation is just a representation

Real defect on real component

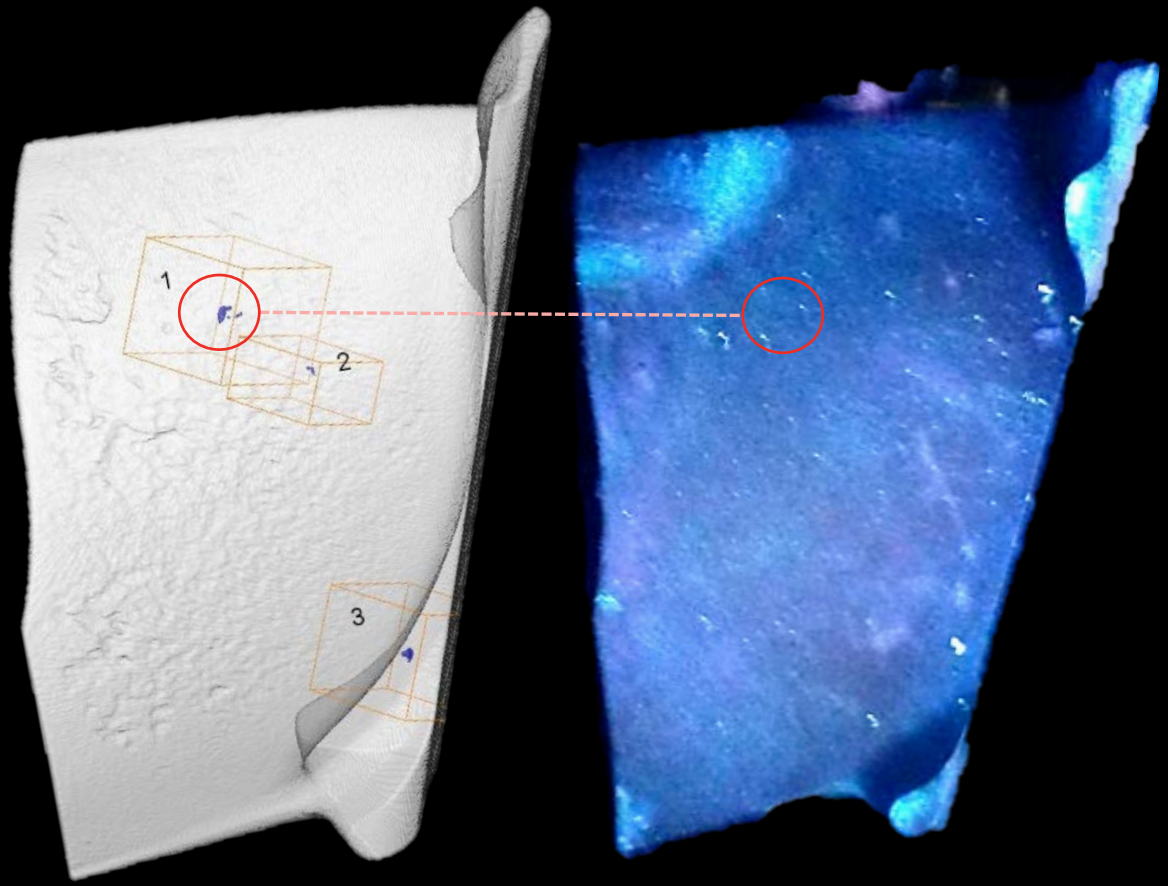
500 kHz scan

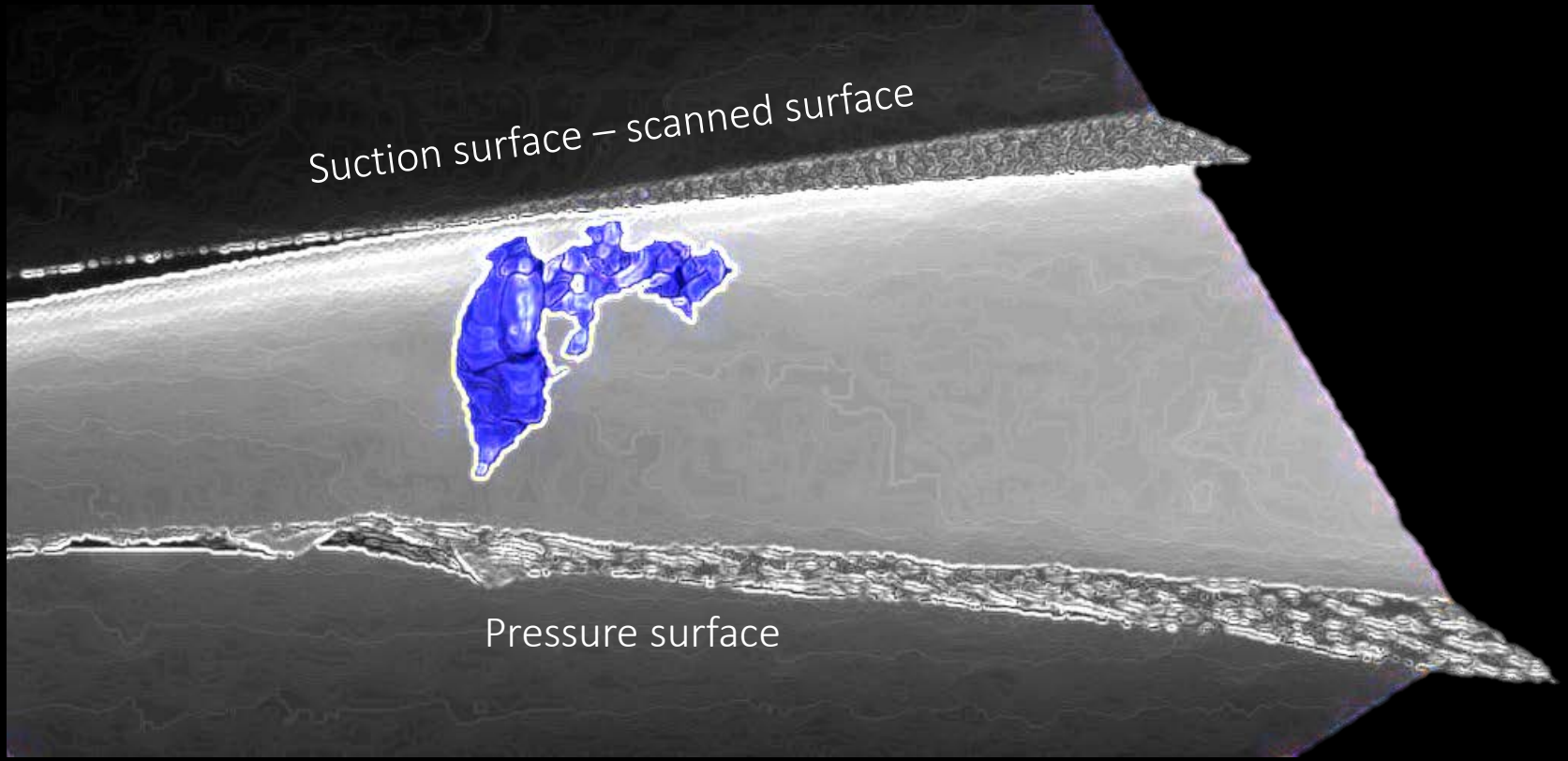


300 kHz scan



35mm





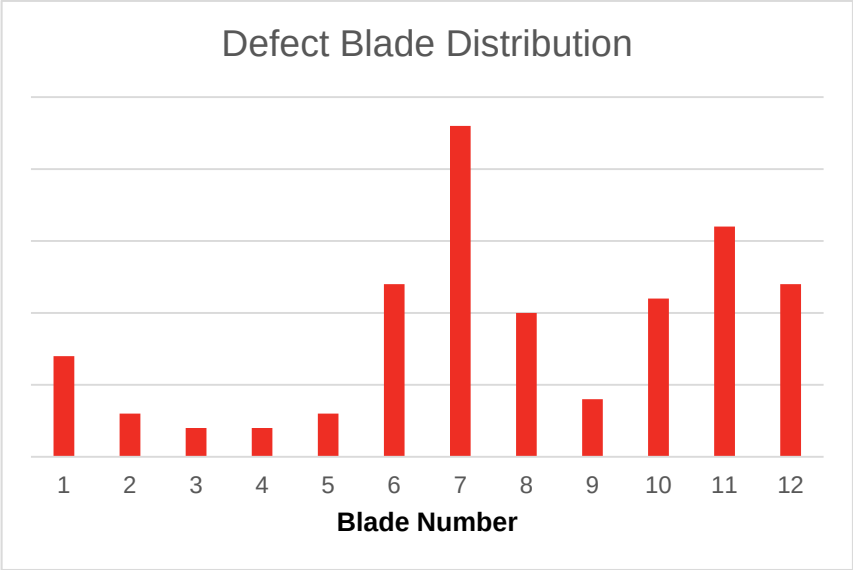
Defect detected by 3DXRCT and analysed at the University of Manchester (MXIF) highlighted artificially in blue

PREVENTION

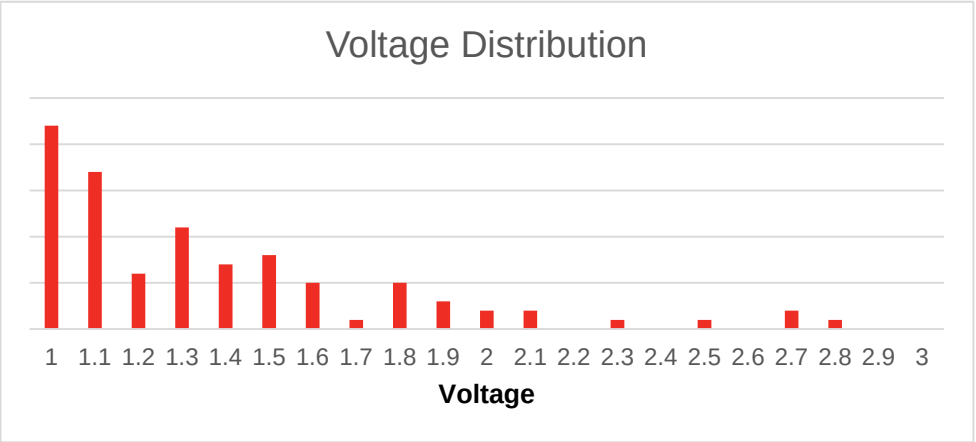
Supplier Collaboration

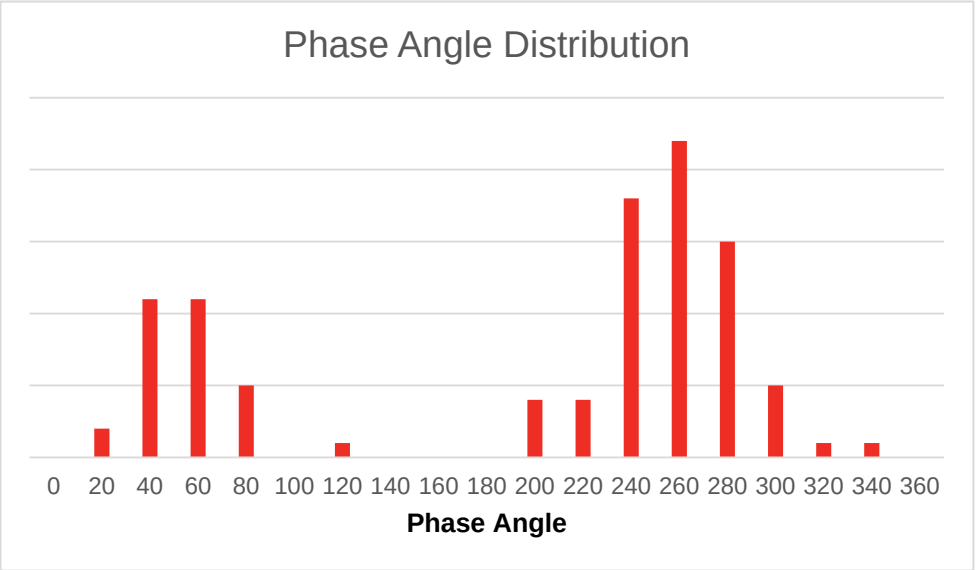
1. **Identify** process that introduces defects into casting
2. **Consider** methods for reducing effect of this process
3. **Monitor** defect count on casting optimisation trials
4. Perform durability tests to **validate** improvements by eddy current inspection

Baseline Results



Blades scanned = 576





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