PCRT Resonance Solutions for Additive Manufacturing

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Abstract. Additive Manufacturing (AM) processes are being used increasingly in aerospace to produce even critical components to the detriment of legacy manufacturing systems like casting, forging or machining. Yet quality assurance tools have to catch up to the challenges posed by these new manufacturing methods: process variation, potential manufacturing defects, long-term stability and capability... all are essential concepts still insufficiently understood that need reliable solutions.

Process Compensated Resonance Testing (PCRT) offers Resonance Solutions to a variety of AM challenges. PCRT can:

• Monitor component consistency to provide manufacturing process control data, correlating final component attributes to process parameters, material (powder) batches, and machine-to-machine variation. PCRT's precise, repeatable part-level data feed big data analytics, and combine with manufacturing and operational data to provide insight not available with other inspection methods.

• Monitor the consistency of critical processing operations such as hot isostatic pressing (HIP) and heat treatment (HT). These operations are critical to the confidence in AM components and manufacturers need certainty that they affect all components similarly.

• Validate models and quantitatively compare legacy and reverse-engineered components. Resonance is an integrity fingerprint to quantitatively verify that what was originally designed has been actually printed.

Emerging PCRT studies of AM parts show detection of porosity-related defects, powder supply variation, build process variation, retained powder and correlation to performance testing. PCRT assures part quality at every state, from verifying that the part printed is the part designed, to tracking the consistency of each and every part produced.

In addition, PCRT is production-line ready, capable of testing parts in seconds, integrated with parts-handling automation, and providing Pass/Fail results without highly trained inspectors.

All these turn PCRT into a powerful tool for the AM community to increase confidence in the manufacturing and inspection environment to allow them to take advantage of its tremendous potential.
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VibrantNDT.de

PCRT
PROCESS COMPENSATED RESONANCE TESTING
Who is **Vibrant**?

Founded in 2006, Vibrant’s **PCRT services** support the worldwide aerospace, automotive and power generation industries, as well as materials laboratories with unparalleled non-destructive testing (NDT).

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**How Does PCRT Work?**

**Ultrasound technology, not focused but a full body inspection using Natural Resonances via swept sine method**

- Based on ASTM E2001-13, E2534-16 and E3081-16

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**Diagram:**
What Does PCRT Measure?

A multi-frequency pattern is the fingerprint or certificate of a component. Fingerprint data is used to classify parts at different stages (during production process, during service life).
Advanced mathematics for evaluation.

Resonance features

- Depend on stiffness and mass
  - Material Properties
  - Production history (powder, laser speed, HIP)
  - Thermal history (heat treatment)
  - Fatigue history
  - Service life
- Integrating: whole body measurement
- Relative: reference set required
- Indirect: no defect localization
- Automatable: independent of user qualification
Additive Manufacturing examples (1)

Use PCRT to …

- Monitor component consistency
  - print position
  - batch to batch
  - powder to powder

- Monitor critical operations
  - HIP (Isostatic pressure)
  - Heat Treatment

Additive Manufacturing examples (2)

Use PCRT to …

- Detect outliers
  - Parts with extensive residual stress

- Validate (Reverse Engineered) Models and Components

Comparison of resonance spectra “as modeled” and “as built” for 2 samples: Part 1 is much more representative of the modeled properties and dimensions than Part 2.
Summary

PCRT = Process Control & NDT
- Based on resonance analysis
- Reflects physical changes
- Use in production or in service
- Track parts with serial number through life cycle
- Reduce risk
- Improve confidence

This is only a brief introduction to the PCRT capabilities.

We look forward to a more in depth explanation and discussion during the session this afternoon.

References

[9] Federal Aviation Administration Approved—Since July of 2010 for the detection of micro-structural changes indicating over-temp of turbine blades (JT8D-219 HPT)