

Summary of Dialogue on Qualification and Certification

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What are the near-term needs for an Additive Manufacturing performance qualification protocol?

- Clear understanding of qualification requirements
- Material Feedstock Pedigree including receiving and recyclability inspection, granularity in the C of A
- Computational modeling: NDT for long-term, phenomenological near-term
- Product (functional) and test requirements, min/max operating environment
- Qualify/Identifying test methods, info, and data that can qualify process as consistent and repeatable
- Final part design, full connectivity within part, water-tight, simplicity
- Standard terminology, standard witness coupons, standard form for recording process parameters
- Identify what specifications need to be locked down and communicated
- Certification Agencies, Customer buy-in at early stages, Fiduciary duty
- Need in process monitoring and controls
- Characterization of typical defects and understanding their effects

What existing qualification protocols cover requirements for Additive Manufacturing?

- Army mil standard 3049, Navy Tech PUB 248, cold spray US ARL
- Source build for baseline producibility, variability
- Factory tests
- Many internal qualification methods exist but are proprietary
 - 3rd party reviewing and disseminating successful common practices for qualification
- Qualify procedures, operators, materials, process, and system to help with end product certification
- Shared databases such as CMH-17 (similar NCAMP process, AWS, MMPDS)
- Investment casting, fixed process controls, casting drawing before engineering drawing
- Welding specifications – essential process variables
- Combine Casting and welding best practices for AM
- AWS B2.1, ASME B+PVC section IX

What is necessary to implement an initial performance qualification protocol for Additive Manufacturing?

- Develop test methods that accurately reflect AM component features
 - E.g. Thin Lattices
- Baseline of machine
 - Proper installation, initial qualification, and manufacturer assisted factory acceptance
- Training for proper operation
 - Use vacuum furnace spec or Zeiss CMM as a template (very controlled and precise)
- Product and process qualification
 - Need to limit to parameters instead of whole process
 - Material and application specific – criticality
- Traceability strategy: from powder to part
- Understanding material properties as a function of process
- AM Equipment must allow capture of all necessary variable
 - Generate list of techniques and variables that can be extracted from each process
- Generate complete understanding of process parameters – near term priority

Continued...What is necessary to implement an initial performance qualification protocol for Additive Manufacturing?

- Identify critical basic controls for each type of platform
 - Basic minimum properties
- Need to allow end users to calibrate and tune machines
- Generate statistically significant samplings
 - Derived end state
 - Variability
 - Controls
- Performance based qualification
- Model and simulation tools as appropriate
- Coupons can be an oversimplification
- Have to understand fundamental, competing physics in process
- Clear understanding of qualification protocol
 - Feedstock, process, performance, test methods
- Regulatory framework for the qualification

How can initial qualification protocol for AM be developed?

- Challenge- start with same material/process and cannot reach same properties
 - 1) Identify the variability
 - How do you provide proof of properties
 - How do you now quantify non-bulk properties
 - 2) Correlate the part functional properties to layer properties
 - Ties into understanding process parameters
- Witness coupons for the process
- Adapt existing protocols
 - Build off of welding and casting standards
 - “Torture” part to test vendor capability – can there be a standard part & material that the industry can agree on?
 - NIST benchmark model 1 and 2 that can be downloaded now
 - Need to figure out how to correlate results from benchmark models back to allowables
- Write draft specs for gap analysis (ref. AWS D20)

How do we move forward in qualification protocols for Additive Manufacturing?

- Standard Test Coupons
 - specific to performance of the process.
 - Representative of process stability
 - Limitations need to be understood
 - Can have good coupon but bad part
- Industry collaboration and communication, working meetings with those operating equipment and user groups
- Low-hanging fruit examples
 - Contest between parts, part history, logistics, supply chain
 - Availability is more important than cost

What are the future goals for quality and certification protocol in Additive Manufacturing?

- Sensors built into machines to determine status in real time
- Repeatable, reproducible and control of variability with any material and any process
- Critical defect study to understand which discontinuities are unacceptable
- Once qualified, permissible range of variation to allow for meeting qualifications
- Statistics and probability testing
- Validated Simulations- physics based models
- Verification and Validation of Quantifiable Part Quality