NRC Public Workshop on Advanced Manufacturing Technologies for Nuclear Applications

Matthew Hiser and Mark Yoo
Office of Nuclear Regulatory Research
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Outline

- NRC Activities on Advanced Manufacturing Technologies (AMTs)
  - 5 Primary Technologies
  - Technical and Regulatory Preparedness
  - Communications and Knowledge Management
- Public Workshop
  - Overview and Approach
  - Summary of Sessions
  - Organization and Logistics

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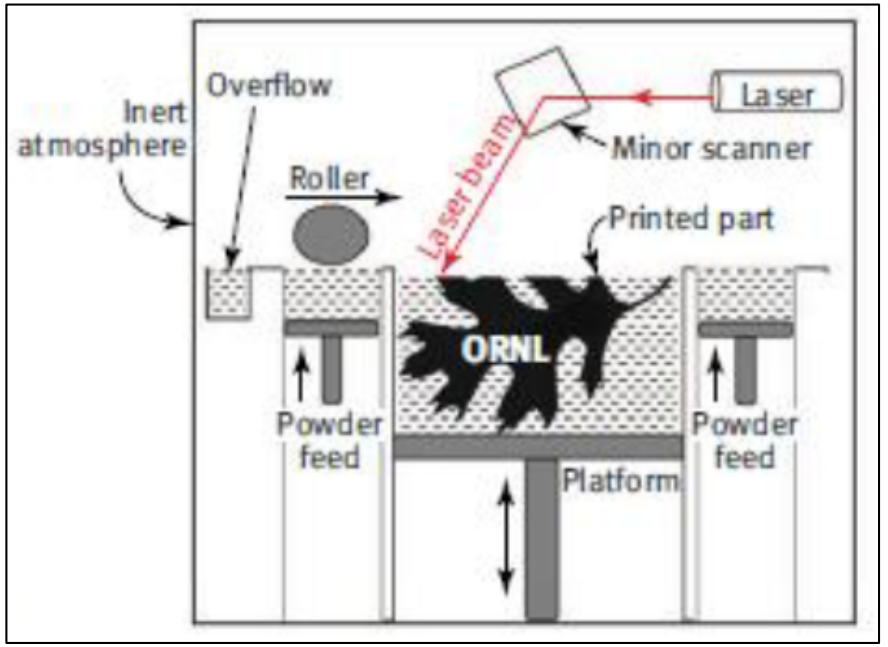
Advanced Manufacturing Technologies

- Techniques and material processing methods that have **not** been:
  - Traditionally used in the U.S. nuclear industry
  - Formally standardized/codified by the nuclear industry
- Key AMTs based on industry interest:
  - Laser Powder Bed Fusion (LPBF)
  - Direct Energy Deposition (DED)
  - Electron Beam Welding
  - Powder Metallurgy - Hot Isostatic Pressing (PM-HIP)
  - Cold Spray

Laser Powder Bed Fusion

- Process:
  - Uses laser to melt or fuse powder particles together within a bed of powder
  - Generally most advantageous for more complex geometries
- Potential Applications
  - Smaller Class 1, 2 and 3 components, fuel hardware, small internals



Schematic of LPBF process*

* https://www.osti.gov/pages/servlets/purl/1437906

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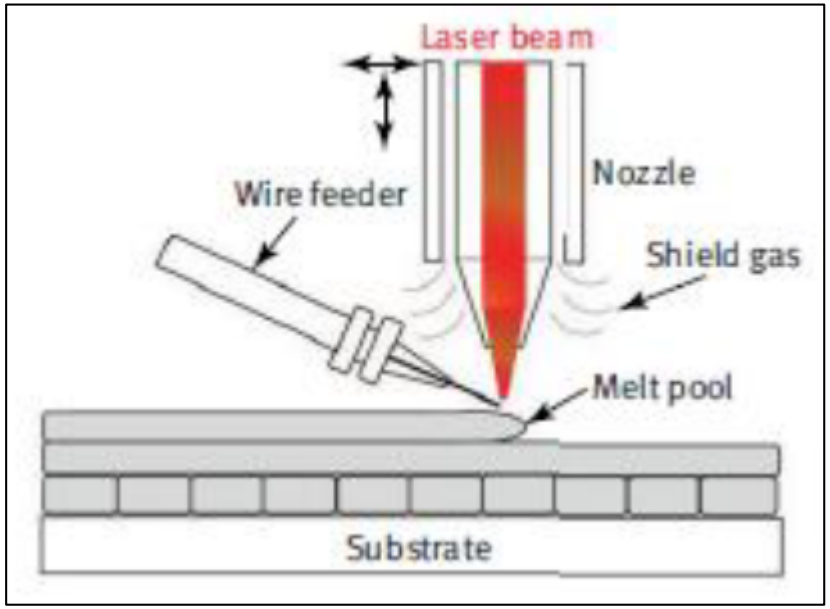
Directed Energy Deposition

- Process:
  - Wire or powder fed through nozzle into laser or electron beam
  - Fundamentally welding using robotics/ computer controls



Schematic of DED process*

- Potential Applications
  - Similar to LPBF, although larger components due to faster production and greater build chamber volumes

*https://www.osti.gov/pages/servlets/purl/1437906

Powder Metallurgy – Hot Isostatic Pressing (PM-HIP)

- Process:
  - Metal powder is encapsulated in a form mirroring the desired part
  - The encapsulated powder is exposed to high temperature and pressure, densifying the powder and producing a uniform microstructure
  - After densification, the capsule is removed, yielding a near-net shape component where final machining and inspection can be performed
- Potential Applications
  - All sizes of Class 1, 2 and 3 components and reactor internals
  - EPRI / DOE focused on use with electron-beam welding to fabricate NuScale reactor vessel

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Electron Beam Welding

- Process:
  - Fusion welding process that uses a beam of high-velocity electrons to join materials
  - Single pass welding without filler metal
  - Welding process can be completed much more quickly due to deep penetration

- Potential Applications
  - For welding medium and large components, such as NuScale upper head

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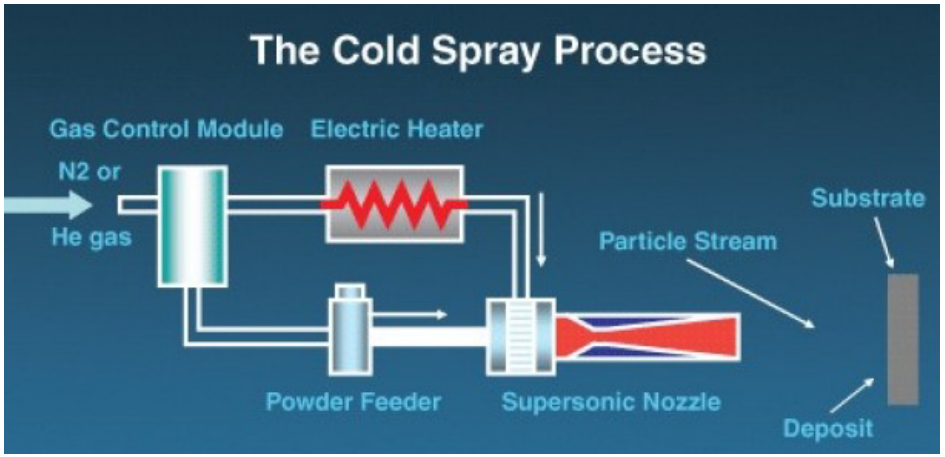
Cold Spray

- Process:
  - Powder is sprayed at supersonic velocities onto a metal surface and forms a bond with the part
  - This can be used to repair existing parts or as a mitigation process



Schematic of cold spray process*

- Potential Applications
  - Mitigation or repair of potential chloride-induced stress corrosion cracking (CISCC) in spent fuel canisters
  - Mitigation or repair of stress corrosion cracking (SCC) in reactor applications

*https://www.army.mil/article/148465/army_researchers_develop_cold_spray_system_transition_to_industry

NRC Action Plan

- NRC activities related to AMTs have been organized and planned through the AMT action plan (Rev. 1 in June 2020 - ML19333B980) with the following objectives:
  - Assess the safety significant differences between AMTs and traditional manufacturing processes, from a performance-based perspective.
  - Prepare the NRC staff to address industry implementation of AMT-fabricated components through the 10 CFR 50.59 process.
  - Identify and address AMT characteristics pertinent to safety, from a risk-informed and performance-based perspective, that are not managed or addressed by codes, standards, regulations, etc.
  - Provide guidance and tools for review consistency, communication, and knowledge management for the efforts associated with AMT reviews.
  - Provide transparency to stakeholders on the process for AMT approvals.

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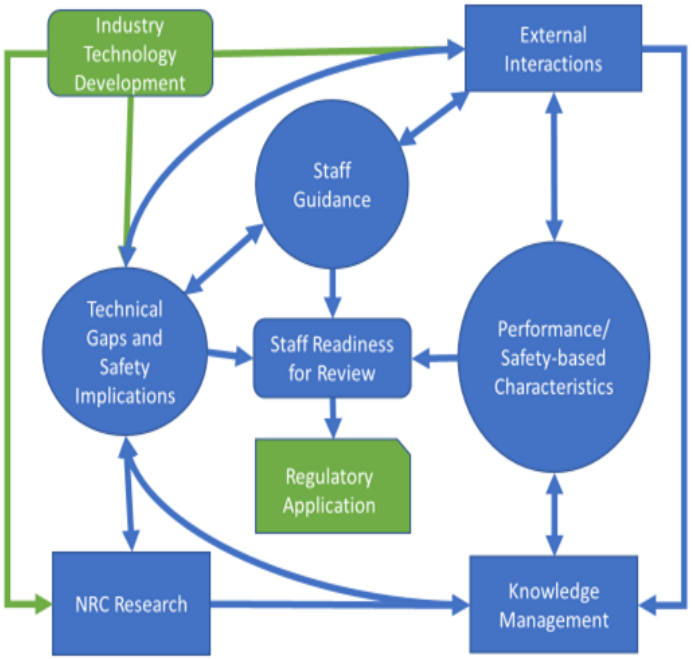
Action Plan – Rev. 1 Tasks

- Task 1 - Technical Preparedness
  - Technical information, knowledge and tools to prepare NRC staff to review AMT applications
- Task 2 - Regulatory Preparedness
  - Regulatory guidance and tools to prepare staff for efficient and effective review of AMT-fabricated components submitted to the NRC for review and approval
- Task 3 - Communications and Knowledge Management
  - Integration of information from external organizations into the NRC staff knowledge base for informed regulatory decision-making
  - External interactions and knowledge sharing, i.e. AMT Workshop



Technical Preparedness Activities

- Subtask 1A: AMT Processes under Consideration
  - Perform a technical assessment of multiple selected AMTs (Laser Powder Bed Fusion, Directed Energy Deposition, PM-HIP, EB-welding, and Cold Spray)
  - Gap assessment for each selected AMTs vs traditional manufacturing techniques
- Subtask 1B: NDE Gap Assessment
  - Assess the state of technologies in the testing and examination of AMTs
  - Will inform staff decisions related to use of NDE on AMT-fabricated components
- Subtask 1C: Microstructural and Modeling
  - Evaluate modeling and simulation tools used to predict the initial microstructure, material properties and component integrity of AMT components
  - Identify existing gaps and challenges that are unique to AMT compared to conventional manufacturing processes

Regulatory Preparedness Activities

- Subtask 2A: Implementation using the 10 CFR 50.59 Process
  - Provide guidance and support to regional inspectors regarding AMTs implemented under 50.59
- Subtask 2B: Assessment of Regulatory Guidance
  - Assess whether any regulatory guidance needs to be updated or created to clarify the process for reviewing submittals with AMT components
  - Complete: ML20233A693
- Subtask 2C: AMT Guidance Document
  - Develop a report which describes the generic technical information to be addressed in AMT submissions
  - Public meeting discussing initial framework was held July 30, 2020: https://www.nrc.gov/pmns/mtg?do=details&Code=20200816
  - Meeting summary can be found here: ML20240A077

Communications and KM Activities

- Subtask 3A: Internal Interactions
  - Internal coordination with NRC staff in other areas (e.g., advanced reactors, dry storage, fuels)
- Subtask 3B: External Interactions
  - Engagement with codes and standards, industry, research, international
- Subtask 3C: Knowledge Management
  - Seminars, public meetings, training, knowledge capture tools
- Subtask 3D: Public Workshop
- Subtask 3E: AMT Materials Information Course
  - Internal NRC staff training

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Workshop Overview

- Location/Dates: Virtual, December 7-10, 2020
- Website: https://www.nrc.gov/public-involve/conference-symposia/amt-workshop.html
- Motivation:
  - Increasing industry interest and plans to implement AMTs for nuclear applications
    - Replacement components in operating nuclear power plants and in initial construction of small modular and advanced reactors.
  - NRC must be prepared to efficiently and effectively regulate and respond to industry submittals that apply AMTs for both operating and future plants.
- Participants
  - Vendors, utilities, EPRI, NEI, DOD, DOE (incl. labs), NIST, NASA, regulators (other U.S. government, international)

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Workshop Approach

- Goal is to have an interactive workshop with multiple opportunities for dialogue
  - Q&A / discussion periods to end each session as well as secondary Teams chat following most presentations
- Objectives:
  - Discuss ongoing activities related to AMTs, including nuclear industry implementation plans, codes and standards activities, research findings, and regulatory approaches in other industries
  - Inform public of NRC's activities and approach to approving use of AMTs
  - Determine, with input from nuclear industry stakeholders and other technical organizations, areas where NRC should focus to ensure safe implementation of AMTs

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Workshop Sessions

- Session 1 – Practical Experience Related to Implementing AMTs
  - Nuclear and non-nuclear industry experience with various AMTs
- Session 2 – Plans and Priorities for AMT Implementation in Commercial Nuclear Applications
  - Nuclear industry plans and interests for using AMTs in NRC-regulated applications
- Session 3 – Performance Characteristics of AMT–Fabricated Components
  - AMT-specific information related to processing and product performance

Workshop Sessions

- Session 4 – Approaches to Component Qualification and Aging Management
  - Nuclear and non-nuclear perspectives on qualification of AMT components
- Session 5 – Codes and Standards Activities and Developments
- Session 6 – Regulatory Approaches for AMTs
  - Nuclear, non-nuclear, and international regulatory approaches
- Session 7 – Research and Development of AMTs
  - Information on key research programs and specific research projects related to AMTs

Workshop Organization

- WebEx will be used for the primary presentations and discussion sessions
  - Please place questions in the chat window during the presentation and we will address as many as possible in the allotted time
  - If you would like to ask your question verbally, please indicate through the chat, so that you can be upgraded temporarily to a panelist to be able to use audio functions
- A secondary Microsoft Teams link will be provided after most presentations to allow presenters to field additional Q&A for 20 minutes
  - Simply click the link provided in the WebEx chat window to join the Teams chat and ask additional questions to the presenter.

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