

NRC Perspectives on Advanced Manufacturing Technologies

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Discussion Topics

- NRC interests
- Industry activities
- Approaches to use AMTs in plants
- NRC AMT action plan
 - Technical topics of interest

What are Advanced Manufacturing Technologies?

- For NRC's purposes, manufacturing techniques and material processing methods that have **not been traditionally used** in the United States (U.S.) nuclear industry **nor formally standardized** by a codes and standards organization.
- Includes:
 - New ways to make hardware (components or other parts)
 - Surface treatments or other processing techniques to provide improved performance

What are NRC's Interests? (1)

- Significant efforts by industry, government (DOE) and universities to develop AMT
- Expect a high level of interest in nuclear power plants
- Many uses of AMTs in nuclear power plants could require NRC approval

What are NRC's Interests? (2)

- With mixed performance of past reviews of new materials, processing techniques, etc., NRC is striving to **identify and develop the regulatory and technical tools that will position us to efficiently and effectively review applications for use of AMT**
 - Consistent with NRC efforts on “Innovation and Transformation”

Nuclear Industry Activities

- Additive Manufacturing (AM)
 - Currently limited items in non-safety related applications
 - Developing test samples for discussion in code committees
- Powder Metallurgy-HIP
 - DOE / EPRI SMR reactor pressure vessel
 - 2/3 scale – upper and lower head
- Electron Beam Welding
- Diode Laser Cladding
- Cryogenic machining

Approaches for Plant Use of AMT

- Non-regulated portions of the plant
 - Experience can inform regulated uses
- 10 CFR 50.59
 - Plant determination that use does not require NRC approval – NRC reviews this evaluation
- Incorporate to ASME Code or standards
 - Could be endorsed by NRC (10 CFR 50.55a)
- Technical report for generic approval
- Plant-specific submittal

NRC AMT Action Plan - Objectives

- Identify generic regulatory challenges and/or efficiencies associated with approval of AMTs for use in nuclear power plants.
- Provide transparency to stakeholders on the necessary information from applicants and NRC's actions associated with review and approval of applications for use of AMTs.
- Facilitate communication within the NRC to ensure consistency on approval of AMTs in different program areas.
- Develop a performance-based, technology-neutral framework for NRC review and approval of applications to use AMTs, which will facilitate a predictable, efficient, and effective review of AMTs within a safety-focused environment.

NRC AMT Action Plan – Topics

- Regulatory Approval Framework
 - Identify success paths from prior reviews
- Technical Evaluation Areas
- External Interactions
 - Industry, Codes and Standards, etc.
- Knowledge Management
 - Technical and process knowledge

Technical Topic Areas

- Quality/reliability of processes, materials, and components for NPPs
- Properties and structural performance
- Service performance / aging degradation
- Inspectability

Action Plan Approach

- Identify opportunities to optimize existing regulatory approval
 - Evaluate past cases for review of AMTs
 - Review existing processes for licensees to introduce AMT
- Review technical evaluation areas to identify performance-based information needed to support submittals, as optimized based on the application of the AMT
- Ensure that external interactions will keep us informed of possible applications to use AMT for readiness purposes
- Provide a technology-neutral framework
- Ensure NRC review readiness for AMT submittals through the use of staff resources and possible contractor support
- Remain flexible to changes in industry approach for AMT use
- NOT approve any specific AMT
- NOT develop a cadre of NRC experts on any specific AMT

NRC Action Plan – Summary

- To address preparation of NRC readiness for review of AMT parts
- Provide for interoffice coordination – reactor side, waste management, research
- Address involvement in standards and codes organizations
- A subject of NRC “Innovation and Transformation” initiative
- Draft expected early 2019

External Communications

- Developing MOU addenda with the Electric Power Research Institute, Inc. (EPRI) and the Department of Energy Office of Nuclear Energy (DOE-NE) to share research results and activities related to Advanced Manufacturing
- Regular contact with DOE-NE and EPRI to discuss progress of research efforts

Summary

- Advanced manufacturing has high potential future utilization by the nuclear industry – “when” and “how many” are the questions
- NRC interest areas
 - The reliability of AMT processing and quality of AMT parts
 - The properties and structural performance of AMT parts
 - Service performance and aging degradation of AMT parts
 - Inspectability
- Codes and standards is a key aspect
- Comparison of performance of parts from AMT and conventional manufacturing process (benchmarking)
- Draft Action Plan expected by early 2019

Back-Up Slides

Quality of Advanced Manufacturing Parts for NPPs

- AM Build Process
 - Critical parameters
 - Directionality
 - Uniformity
 - Surface roughness
 - Density
 - Feed stock and powder reuse
- Post-Build Processing
 - Densification (e.g., Hot Isostatic Pressing)
 - Annealing and heat treatment
 - Surface processing
 - Residual stresses and geometric stability

Properties and Structural Performance

- Properties
 - As-built
 - After post-build processing
 - Coupons vs. component
 - Fatigue performance
 - Comparison to conventional manufacturing methods
- Defect Characteristics/Populations
 - Type
 - Size
 - Density
 - Impact on structural integrity

Properties and Structural Performance

- Inspectability
 - In-process examinations
 - Methods capable of finding structurally relevant defects
 - Pre-service inspections
 - Inservice inspections
- Component residual stresses

Service Performance / Aging Degradation

- In various service environments
 - Aqueous (BWR/PWR/Raw)
 - Corrosion
 - Stress corrosion cracking (SCC)
 - Environmental fatigue life
 - Environmental fatigue crack growth
 - Neutron effects
 - Loss of fracture toughness
 - Swelling
 - IASCC
 - Thermal effects
 - Loss of fracture toughness
 - Thermal expansion

Codes and Standards Aspects of AM

- American Society of Mechanical Engineers (ASME)
- ASTM International
 - formerly American Society for Testing and Materials
- American National Standards Institute (ANSI)
- American Society for Nondestructive Testing (ASNT)
- NACE International
 - formerly National Association of Corrosion Engineers