Utility Perspective on Implementing on Advanced Manufacturing Technologies in LWRs

> Lee Friant, PhD Sr. Staff Engineer Exelon Nuclear



Utility View of New Technologies - Inertia

Governing Law:

Newton's first law states that every "object" (read "Nuclear Utility") will remain at rest or in uniform motion in a straight line unless compelled to change its state by the action of an *external force.*



External Forces Driving New Technology in Nuclear

Cost Savings

- ✓ Purchase Price
- ✓ Maintenance
- ✓ Radiological Dose
- Lack of Availability
 - ✓ Obsolescence/Supplier out of business
 - \checkmark Too long lead time to deliver
 - ✓ Only off-shore suppliers (unknown quality)
- Corrects long-standing problem/reliability/safety issue with an existing component design
 - Material failures; e.g., cracking, erosion, corrosion, wear, etc.
 - ✓ Regulatory Compliance



How Can Advanced Manufacturing Technologies Address Nuclear Utility Needs?

➢Cost Savings

- ✓ Not likely initially, but lower Life-cycle Cost
- ► Lack of Availability
 - ✓ Ability to reverse engineer components
 - ✓ 3-D print of "one-off" items
- Corrects long-standing problem/reliability/safety issue to prevent /mitigate failures
 - ✓ Upgrade to non-susceptible base metal
 - ✓ Surface Repair / Apply "protective" coating



AMT Implementation Barriers

- Lack of Utility familiarity with AMTs unique capabilities/limitations
 - ✓ EPRI, NEI (Task Force) and NRC are addressing this gap
- Lack of ASTM Standards/ASME Codes for AMTs
 - ASME Sub-committee formed; first one submitted for review
 - ✓ Will take years to obtain design allowables and to develop and adopt standards for all AMTs
 - Need to "borrow"/adopt from other Industries e.g., Powder Metallurgy and Electron Beam Welding are "mature" technologies outside of Nuclear
- Regulatory framework under development
 - ✓ Structural ASME Class 1, 2 and 3 Components will have to wait unless NRC permission granted through ASME Code relief process



Where Can AMTs be Implemented at Utilities Near-term?

- Replacement and/or Repair of Non-Code Components
 - ✓ Non-structural
 - ✓ Non-pressure retaining
 - ✓ No safety impact (based on 10CFR 50.59 Screening)
- **Exelon example:** Westinghouse Thimble Plugging Device made by Laser Powder Bed Fusion (installed in plant in Spring 2020)
- Coatings for Corrosion / Oxidation Prevention

Exelon examples:

- ✓ Full length Cold Spray "accident tolerant" coating on 16 Fuel Rods (installed in plant in Spring 2019)
- ✓ Cold Spray of Titanium/Titanium Carbide for Crevice Corrosion Mitigation in spare flanged Salt water piping components (Flow Element, 11/20 and Nozzle Check Valve, 12/20).
- ✓ PWR Steam Drum, In-situ Cold Spray of Primary Moisture Separators for Flow Accelerated Corrosion (FAC) Mitigation (2015, 2021 to 2024).
- Balance of Plant Applications at Nuclear Plants
 - ✓ Turbine components (e.g., blades)

PWR Steam Generator Steam Drum Access to Primary Moisture Separators



Lessons Learned From AMT Implementation

- Suppliers developed AMTs then shopped around to interested Host utilities
 - Utility personnel unprepared to accept AMT due to lack of technology familiarity (e.g., critical characteristics such as porosity, toughness, etc.), lack of Procurement and Design Specifications and Code precedent
- Start with simple geometries (rods, tubes, pipes, etc.)
- Most AMT hardware doesn't lend itself to in-plant applications; pick components which are new or spares that can be fabricated / refurbished off-site
- Cold Spray shows promise for in-plant repair applications
- Need to educate and coordinate large number Stakeholders to implement any AMT
- Leveraged DOE Funding AMT not realized at Exelon without DOE support! Thanks!

Fxelon Generation.

It Takes a Team Effort.....

- Many Stakeholders needed to be coordinated and engaged to implement AMT; at Exelon these included:
 - Design and Strategic (Plant) Engineering (outside reactor vessel) / Reactor and Fuels Engineering (inside reactor vessel)
 - ✓ Procurement Engineering
 - ✓ Supply Chain
 - ✓ Programs Engineering
 - ✓ Non-destructive Examination / In-Service Inspection
 - ✓ Maintenance
 - ✓ Warehouse / Shipping
 - ✓ Machine / Weld Shop
 - ✓ Regulatory Assurance
 - Planning / Work Management
 - ✓ Finance
 - ✓ Corporate and Site Leadership

Takeaways

 Set realistic objectives and timetables
 Implementing a first-of-a-kind AMT application is a challenge and requires patience and perseverance; be prepared for a lot of questions, meetings, emails and "hand holding"

- After the AMT process qualification and all the "Nuclear infrastructure" to accept AMT is in place, the 2nd implementation is easy.
 - Exelon example: Cold Spray of 1st Salt Water
 Component: ~ 3 yrs; 2nd component: 2 weeks