The ‘Big Picture’ Vision for AM in Nuclear Industry

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Meeting at NRC, November 28 & 29, 2017

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What is Driving Additive Manufacturing for Nuclear

Delivering the Nuclear Promise:
"Advancing Safety, Reliability and Economic Performance"

In order to facilitate this industry initiative Westinghouse believes the industry needs innovation.

Additive is innovation in the form of a disruptive technology.

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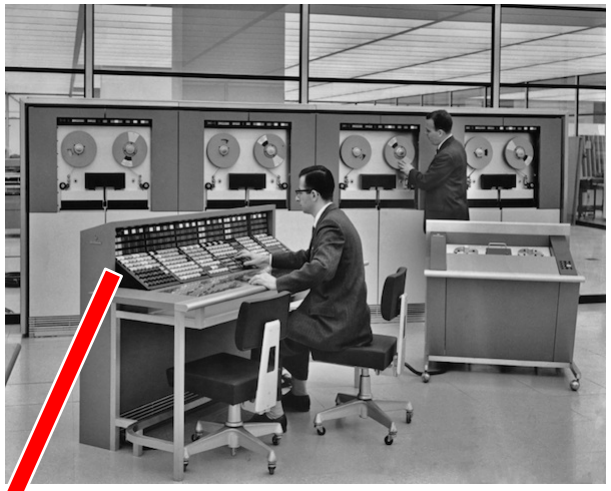
Additive and Nuclear

Additive is a disruptive technology

- Harvard Business School professor Clayton M. Christensen coined the term disruptive technology.
- A disruptive technology is one that displaces an established technology and shakes up an industry or a ground-breaking product that creates a completely new industry

Some examples of disruptive innovation include:

Disruptor	Disruptee
Personal computers	Mainframe and mini computers
Mini mills	Integrated steel mills
Cellular phones	Fixed line telephony
Community colleges	Four-year colleges
Discount retailers	Full-service department stores
Retail medical clinics	Traditional doctor's offices



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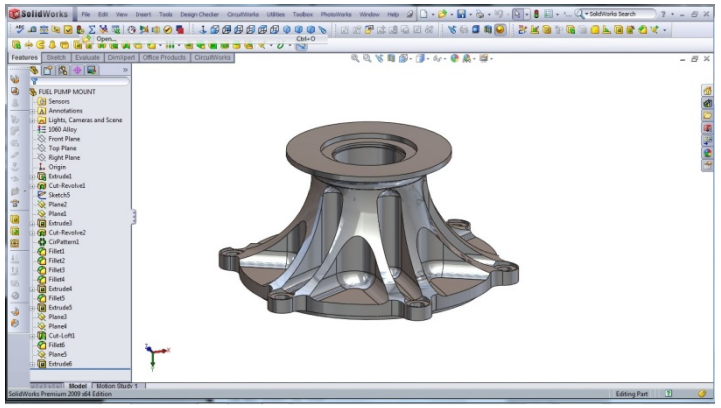
Additive and Nuclear

Additive is a disruptive technology

1. CAD Model
2. Die
3. Wax pattern
4. Mold
5. Casting
6. Machining



1. CAD Model
2. Printed part

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Additive and Nuclear

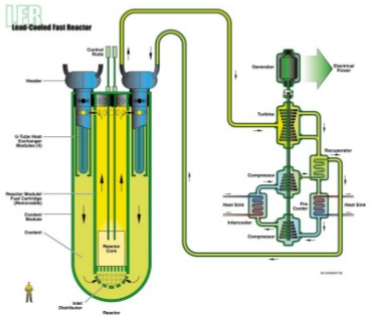
Additive shaking up the Nuclear industry

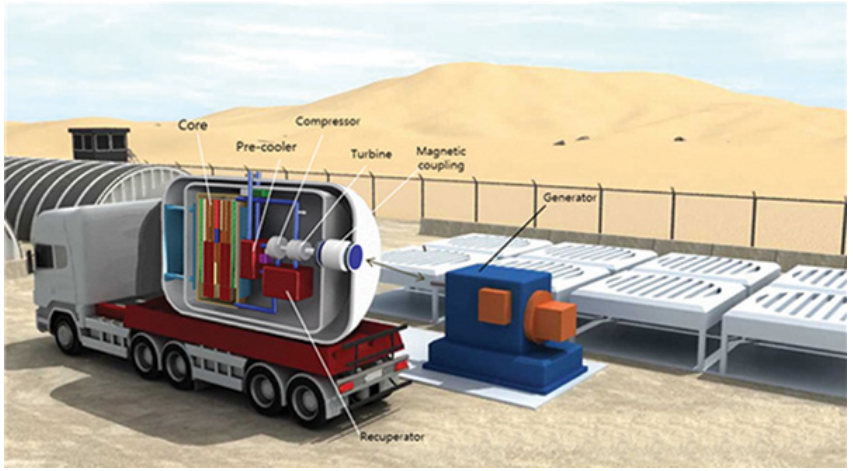
- **Potential to facilitate:**
  - Small Modular Reactors
  - Micro Reactors
  - Advanced Reactors
- **Improved safety**
  - Accident tolerant fuel
  - Sensors

Lead-Cooled Fast Reactor (LFR)

Characteristics
- Pb or Pb/Bi coolant
- 550C to 800C outlet temperature
- Small transportable system 50-150 MWe, and
- Larger station 300-1200 MWe
- 15–30 year core life option

Benefits
- Distributed electricity generation
- Hydrogen and potable water
- Replaceable core for regional fuel processing
- High degree of passive safety
- Proliferation resistance through long-life core





- **Improved economic performance**
  - New design enhancements
  - Flexibility
- **Improved reliability**
  - Replacement parts

Potential to facilitate multi nuclear industry initiatives

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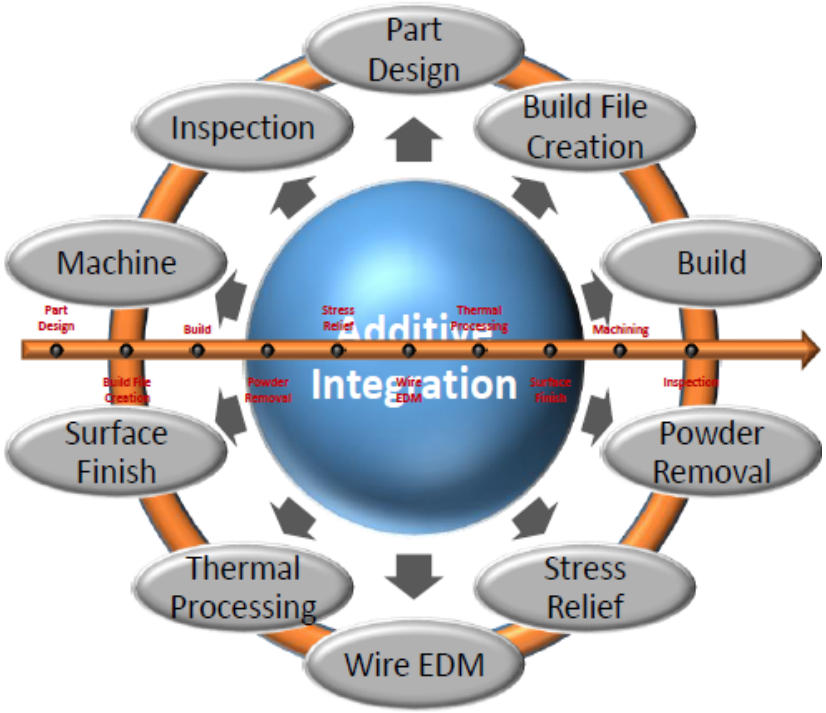
Full Integration is the Key to Success

- Additive Manufacturing cannot be treated as standalone
  - 3D printers are "**just**" another machine tool
  - no one machine tool can do it all
- Design for Additive Manufacturing (DFAM) must be employed
- All aspects of the production process are interdependent
- 3D printers must be combined with traditional manufacturing processes



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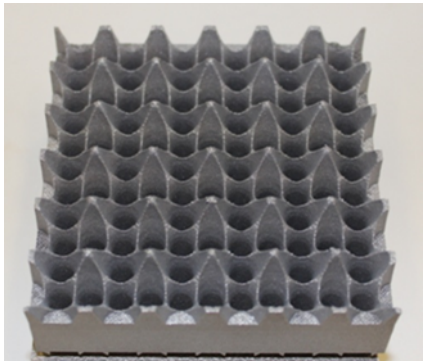
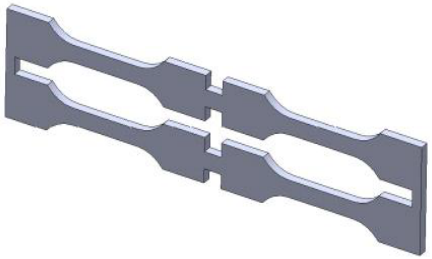
Additive Manufacturing - 3D Printing for Nuclear

- Develop and test critical nuclear materials: 316L, Alloy 718, and Zirconium
- Produce a reactor ready test component
- Exploit the benefits of Additive Manufacturing
  - Producing components with: Powder Bed Fusion, Binder Jetting, and Directed Energy Deposition AM technologies
  - Obsolete and high value / lead time components
  - Next gen plant components - SMR, LFR, …
  - Prototypes, mockups, jigs / fixture, tooling, etc.
- Support the development of codes and standards
  - Participating on ASTM F42 subcommittees
  - DOE funded project: Qualification of AM for Nuclear
- Development Needs:
  - Additional material development and testing to support the development of code & standards
  - Cost effective, large scale equipment
  - AM suppliers with Nuclear programs





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Summary

- Will Additive Manufacturing have a big impact in Nuclear ?
  - Be Cost Effective
  - Improve Performance and Reliability
  - Improve Delivery and Schedule
- In Westinghouse we have started to move in the AM direction:
  - Utilize 3D printing now for tooling
  - Implement a 3D part in reactor to gain experience
  - Perform mechanical tests on 3D parts (with and without radiation effects)
  - Investigate what parts make sense to build with AM

Our Goal is for AM to Help Transform the Nuclear Industry and Support the Nuclear Promise

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