ADVANCING ADDITIVE MANUFACTURING IN AEROSPACE

EWI®
We Manufacture Innovation

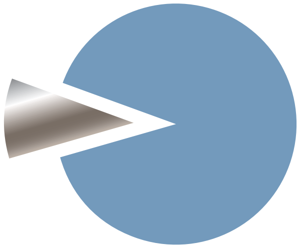
AM-AER014

ADDITIVE MANUFACTURING

Aerospace is leading the way in adopting additive manufacturing (AM) for the manufacturing industry. AM allows aerospace manufacturers to quickly and cost-effectively produce highly customizable geometrically complex components, quickly produce replacement parts, and modify current designs for increased performance. Incorporating printed parts reduces weight, increases fuel efficiency, and reduces material usage.

- The global additive manufacturing market is expected to reach $3.5 billion by 2017

- Aerospace and Defense represent over 10% of the global AM market



http://www.marketsandmarkets.com/PressReleases/additive-manufacturing.asp
http://dupress.com/articles/additive-manufacturing-3d-opportunity-in-aerospace/

INDUSTRY AT A GLANCE

INDUSTRY DRIVERS

- Weight savings
- Space optimization
- Structural optimization
- Reduced joining (printed assemblies)

INDUSTRY NEEDS

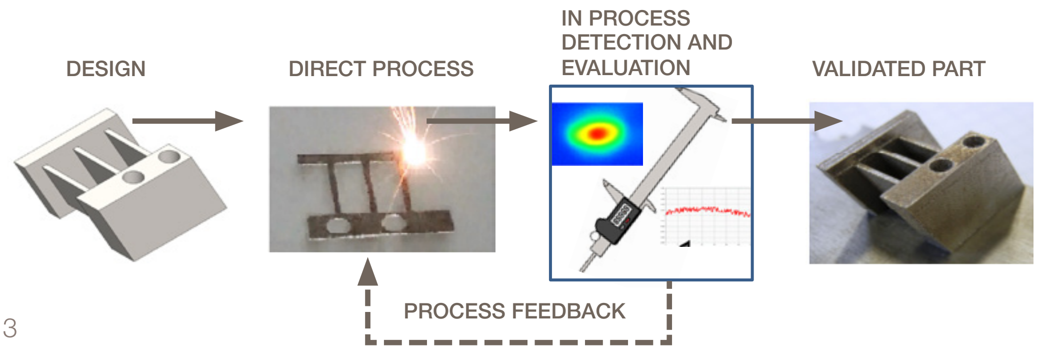
- In-process quality control and post-process inspection
- Materials development
- Heat treatment development
- Engineering data design
- Larger, faster machines

IN-PROCESS QUALITY CONTROL

By and large, industrial 3D printing machines capable of producing metal AM components have limited quality monitoring capabilities. Because these machines were originally developed for rapid prototyping, robust processes and post-process inspection are now used to assure quality. Effective quality monitoring technologies are necessary to move to true additive manufacturing. The end goal is layer-by-layer inspection of the component as it is being created.

Building on our technical depth in developing in-process sensors for weld monitoring, EWI is evaluating a variety of in-process sensors on an open architecture laser powder bed fusion system. We are developing sensors, defect detection algorithms, and

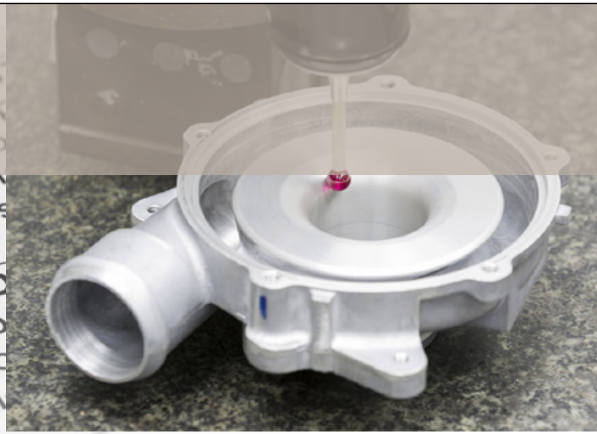
machine modifications necessary to implement on existing and future machines.

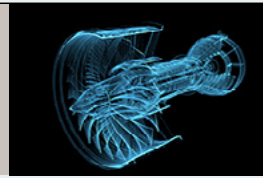


POST-PROCESS INSPECTION

As industry moves towards production of components using 3D printing processes, post-process inspection techniques must be developed. Post-process inspection will complement in-process inspection techniques for defect detection and dimensional tolerance. Complex features, surface finish, and material microstructures may limit the use of conventional inspection techniques.

EWI is involved in several projects evaluating and improving nondestructive inspection techniques for AM, including developing





inspection of x-ray computed tomography, and inspection techniques for improved ultrasonic inspection.

MATERIAL AND PROCESS DEVELOPMENT

The application of AM technology is limited by the number of developed engineering materials available for metal 3D printing processes. Parameter sets consist of approximately 75 variables and are dependent upon the different types of surfaces present. Metal AM processes are fundamentally fusion welding processes and require an understanding of the process physics for successful development.

- EWI is a materials development partner for EOS North America and has developed process parameters for a number of alloy and stainless steels, nickel alloys, and refractory metals.
- EWI is able to develop process parameters for laser- and arc-directed energy deposition, and in late 2015 will expand this capability to the EB-PBF platform

- As part of the 2015 Additive Manufacturing Consortium (AMC) projects, EWI is developing parameters for nickel alloy 400 and is exploring aluminum alloy development equivalent to 6xxx and 7xxx series.

HEAT TREATMENT DEVELOPMENT

Conventionally manufactured materials often require heat treatment to develop the correct combination of material properties. Metals produced by 3D printing also require heat treatment, but the response may be different than conventional alloys.

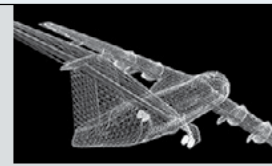
EWI is working with customers to develop optimized heat treatments for materials produced by metal 3D printing processes, including identifying treatments to minimize or eliminate anisotropy in material properties.

The AMC is currently looking at developing heat treatments for nickel alloys 625 and 718 in a collaborative and precompetitive environment.

PROPERTY DATABASE DEVELOPMENT

Designers require statistically significant and validated material property data in order to generate new designs using AM. The materials produced in AM machines are sensitive to the production method, process, and orientation. The cost of these testing programs is prohibitive for small and medium-sized manufacturers, and often too costly for larger companies to go it alone. Furthermore, standards bodies are still determining the best way to generate these datasets.

- EWI is working with our government and commercial customers to develop these foundational datasets by using rigorous documentation and thoughtful test plan design.



- Through the AMC, we have developed initial material property data for nickel alloy 625 and 718 and have developed a method of establishing data pedigree.

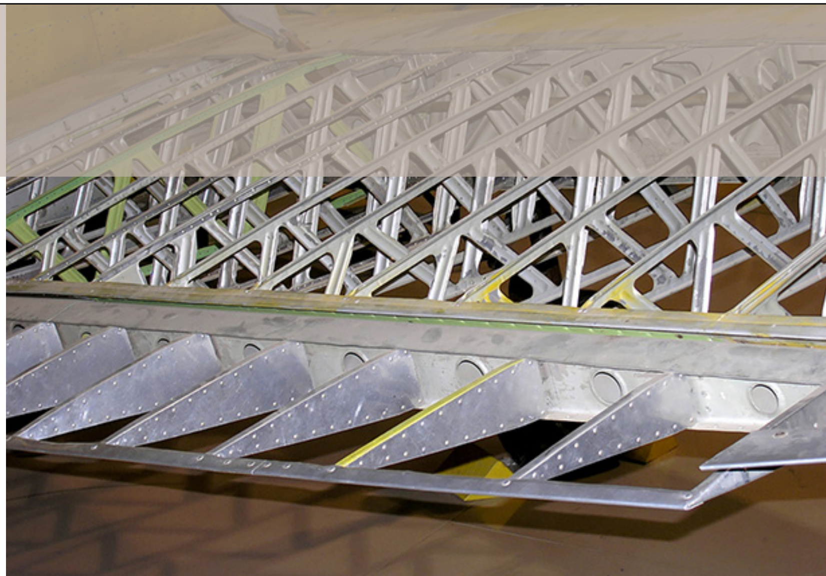
NEXT GENERATION AM MACHINES

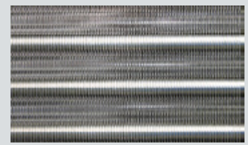
Current commercially available machines are limited in the size of the components that can be produced. These machines may trade process speed for surface finish and may not be suitable for high-rate production.

- EWI is investigating equipment and process changes to enable order-of-magnitude changes in production rate through the use of multiple energy source types, application specific process strategies, and intelligent path planning.
- EWI will be investing in hybrid (additive and subtractive) technologies.

EWI CAPABILITIES

- Multiple robotic and CNC workstations with capability to ~10m in length
- Laser power to 20kW, multiple arc deposition methods
- Planned: hybrid additive + subtractive capability, multiple process machines





MOVING AM FORWARD

WHERE AM IS TODAY:

- Largely rapid prototyping machines
- Limited QA/QC
- "One-size-fits-all" machines
- Developing manufacturing process chain, including standards, heat treatments, material data, post-process inspection, qualification and certification methods
- Suitable for low production volumes, limited size
- Limited skilled staff resources

WHERE AM IS HEADING (3-5 YEARS):

- Application-specific, robust manufacturing machines with in- and post-process QA/QC fully developed
- Lessons learned from aerospace technology adoption
- Established standards
- The expertise to take advantage of process-specific alloys and material architectures
- Knowledgeable resource pool of entry-level engineers

MOVING AM FORWARD CONTINUED

EWI develops, demonstrates, and advances metal Additive Manufacturing processes to enable broader adoption of the technology by industry through:

- **Maintaining** a holistic view of the technology
- **Focusing** in metals AM technology development across the manufacturing chain
- **Developing** non-rapid prototyping uses for polymer AM products
- **Exploring** ceramics and novel material development
- **Operating** the Additive Manufacturing Consortium

ABOUT EWI

EWI helps aerospace manufacturers reduce the risks associated with innovation by showing them how to apply advanced technologies to improve the performance, quality, and manufacturability of aircraft components while reducing life-cycle costs. Our extensive work with next-generation high strength steels (AHSS), advanced welding and materials joining technologies, additive manufacturing, advanced non-destructive evaluation (NDE), computational modeling and simulation, and aerospace technologies gives our customers a definitive advantage. To learn more about EWI's experience helping aerospace manufacturers and suppliers use technology innovation to become more competitive, contact **Brian Bishop, Aerospace Business Development Manager,** at **bbishop@ewi.org** or **614.270.7052**

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