Key Considerations for Metal AM Parameter Optimization

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Additive manufacturing (AM) has developed way beyond its inception as a mere rapid prototyping technology. It now presents itself as a viable alternative manufacturing process for fully functional parts. However, the non-recurring engineering costs involved to take an AM part from concept to production are significant, as the industry is yet to define "what really matters" for these parts. The ever-growing number of AM OEMs, material suppliers, and auxiliary AM service providers make it even more complicated and confusing to select the right set of tools for an application. Even if one does manage to down select an AM technology and material for their application, each system offers a wide variety of processing parameters that must be considered to achieve the desired results based on an application.

The term "optimize process parameters for additive" is commonly used in the AM world. But these process parameters can mean many things. In order to bring a new part to market, the AM process cycle (Figure 1) progresses from identifying the correct material source, characterizing the raw material, identifying the correct machine parameter window for deposition, developing the stress relief and heat treatment parameters, identifying the correct post finishing technique, and finally determining the correct NDE technique for inspection. All of this involves optimization to determine the ideal parameter sets based on functional part requirements.

The definition of part requirements and their relationship with AM machine process parameters is tricky, too. There can be multiple ways to achieve the same part requirement. For example, one might want to optimize machine parameters to meet predefined mechanical properties. This can be done 1) by focusing on optimizing AM machine parameters to build fully dense parts with a certain microstructure which may lead to long processing times, or 2) by focusing on optimizing the heat treatment cycle and building parts relatively fast

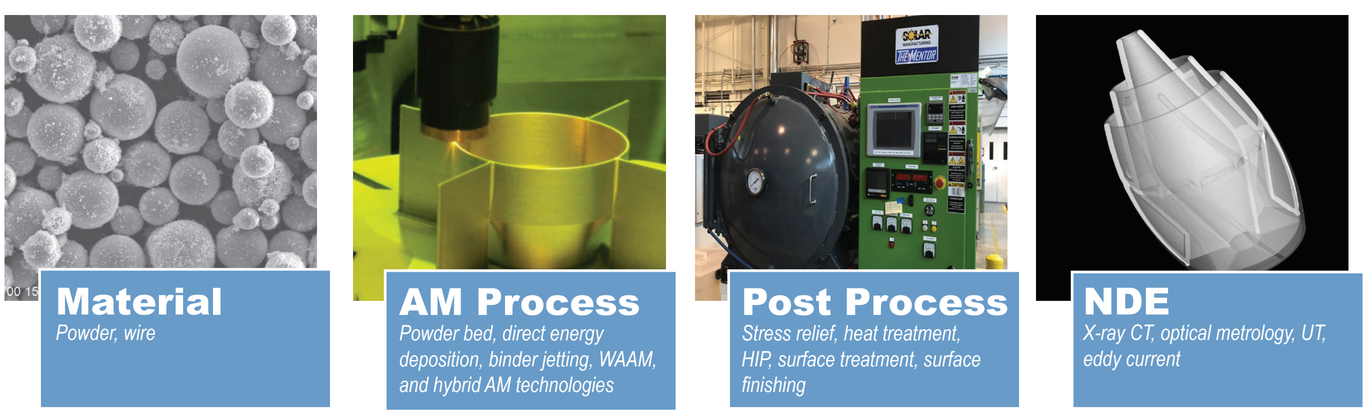

Figure 1. AM process cycle selection.

Product Requirement	Optimize for...	Why does it matter?
Properties	Density	Affects part performance governed by mechanical properties like tensile, fatigue, creep and elongation
	Microstructure	Affects part performance governed by mechanical properties like fatigue, creep, hardness and elongation
	Chemistry	Affects part microstructures thus the inherent mechanical properties as well.
Geometry	Dimensional Accuracy	Affects part fit in an assembly
	Surface finish	Affects fatigue life, fluid flow characteristics, and part fit
	Feature resolution	Affects part functionality
	Minimal support	Adds post finishing effort, thus increases cost.
Cost	Time	ROI
	Throughput	ROI
	Low cost material	ROI

Table 1. Product requirement optimization examples.

depending on the material. Table 1 gives an overview of some of the product requirements, the factors for which one can optimize, and how that actually affects the end application.

There is no "machinist's handbook" today to help engineers walk through the many factors to be considered when manufacturing a good AM part. Some AM machines come with 1,000+ parameters that each influence the build process in some way, shape or form. In addition, AM processes can be very sensitive to slight changes in any input parameter; be it the raw material, production environment or machine parameters. We have observed that even when a raw material meets defined material specifications, it may be necessary to rework the AM machine process parameters to produce consistent parts when the material supplier is changed. Different material production techniques (and even material producers) can affect build conditions even when characteristic properties such as size distribution, chemistry, flow, and density meet the specs.

Though complex, these intricate co-relations are being worked out within the AM user community. EWI has been at the forefront of this work for more than ten years, and our in-house state-of-the-art equipment includes all seven ASTM F42 AM technologies. We continually invest in internal research and development to ensure that our methodologies are cutting edge. In addition, EWI's 40-member Additive Manufacturing Consortium (AMC), established in 2010, works to further industry collaboration, support, and pre-competitive research. EWI was recently awarded the ASTM AM Center of Excellence in partnership with Auburn University/NASA. For more information on EWI's work in Additive Manufacturing, please contact Rutuja Samant at rsamant@ewi.org.

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