3D Metal Printing Study:
Achieving A Seamless LPBF Production Loop

Advanced Laser Powder Bed Fusion (LPBF) Parameterization Trial on Renishaw RenAM500Q
Conducted by: AMS, Renishaw, and Dyndrite

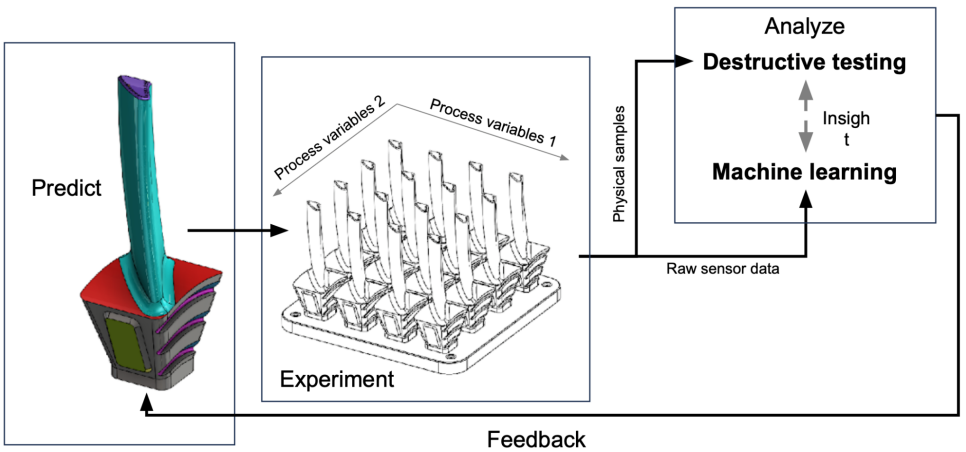
In this research collaboration between AMS, Dyndrite and Renishaw, we are focused on creating an array of aerospace blade singlets, also known as fir tree root blades. Each of these blades will undergo systematic variations in parameters, such as power, speed, and feeds, within specific geometric areas of interest (i.e. leading edge). This approach allows for a Design of Experiments (DoE) study, in which we systematically modify build conditions and analyze their effects on the geometry.

Background:

- Dyndrite is a 3D software developer that provides AM specialists with powerful tools to control their additive manufacturing process. Dyndrite LPBF Pro empowers materials scientists and engineers to dramatically improve, speed up, and lower the development cost of their material development. Unique technologies, such as the CAD feature identification via geometric query capability and programmatic APIs, give users precise control over exactly where and how to assign parameters to each part.
- Dyndrite's Toolpathing API surpasses current layer-by-layer based Boolean toolpathing methodologies by utilizing its GPU-based voxel engine,enabling 3D Volumetric Segmentation or advanced 3D geometric queries into a part.
- The utilization of 3D Volumetric Segmentation empowers the use of geometry to systematically define precise process parameters for components. This facilitates the generation of a vast array of geometric regions or zones within parts, each having distinct parameters applied during the manufacturing process, allowing for limitless variations in the build conditions.

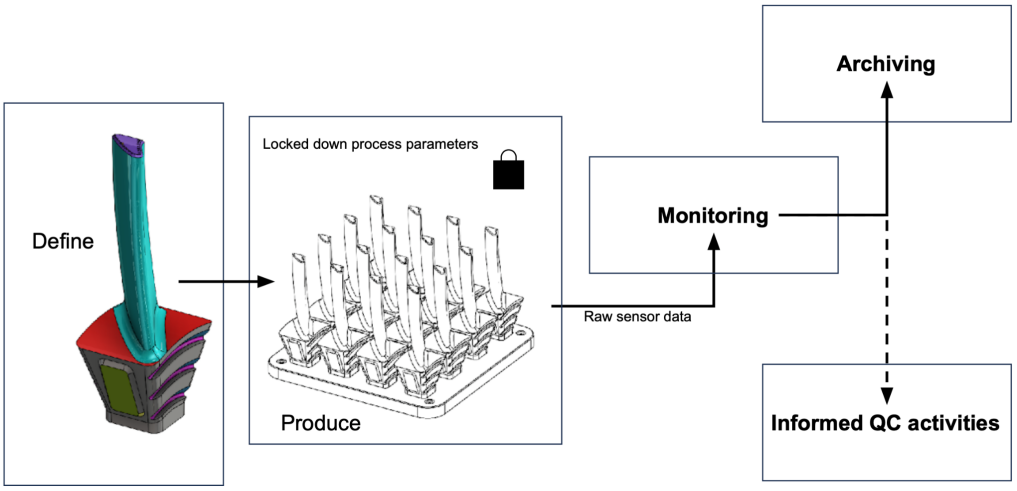
Learning Loop:

Anticipated physical regions of interest, generated and manipulated with Dyndrite, guide the creation of an experimental array by Renishaw. This array is meticulously constructed and monitored, followed by traditional physical and destructive testing. The resulting raw data is then analyzed using machine learning (ML) tools. Insights derived from both ML and physical analysis inform the subsequent iteration of predictions. Dyndrite LPBF Pro facilitates the effective deployment of parameters and manipulation of the object.



Production Loop:

We aim to achieve a seamless production loop, where a specific production geometry and schema are defined and maintained. Continuous monitoring of the manufacturing process using machine learning (ML) enables precise quality control (QC) procedures, ultimately reducing labor, cost, and inefficiencies. Instead of storing large volumes of raw data, we archive the ML decisions alongside only the relevant raw data that influenced those decisions, alleviating extensive storage demands. The advancements in learning and production control through Dyndrite result in a significant enhancement in additive manufacturing (AM) productivity.



Results:

Using Dyndrite's superior geometry region segmentation we have been able to create advanced complex toolpaths for the RenAM500Q machine over those normally generated with similar software. In this Design of Experiments we deliberately control and vary the laser power along the leading edge of an array of blade singlets, one of the most critical functional areas for performance and quality control. Exaggerated for visual effect here, the range of samples show increasing thermal input across blade samples to the point of deliberate non-conformance and poor build quality.

This novel approach shows how optimal print parameters can be systematically derived, and a functional process engineering window explored using Dyndrite software with the Renishaw QuantAM's API to allow complete control of RenAM500 series laser parameters to make more performant parts faster, especially using multi-laser systems.

These results also offer the possibility to use simulation software to define the regions, again accelerating development and, during print, the ability to use machine learning to identify areas for subsequent further parameter refinement.

To learn more:

Dyndrite

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