Critical Part Production: How to Guarantee Consistent Quality

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As the Additive Manufacturing industry moves more towards end part production, especially of critical parts, the question of how to guarantee consistent quality while maintaining a positive business case becomes more relevant. The answer to that question can be found by learning from the hundreds of years of manufacturing experience behind us and applying that to this new technology.

The first element of a controlled process is locking down the variables as much as possible using process controls and documentation (PCD). This can be challenging with a technology that is changing and improving every day, but at some point, a line needs to be drawn with no changes implemented after that. Some elements of the PCD include a calibration, verification, and maintenance plan to ensure the machine is physically operating in a consistent manner. Other elements of the PCD include contamination control, powder handling, and configuration control of the machine hardware, operating software, and process parameter themes. Once a producer has all these elements under control, they can begin to look at how they demonstrate consistent quality to their Customer.

Figure 1: Nozzle as Printed

There are conventional inspection techniques such as dimensional inspection through CMM or structured light, 2D or 3D radiography, fluid penetrant inspection, microstructural evaluation, and proof tests that can be utilized to demonstrate a Customer's requirements have been satisfied. Unfortunately, these tests can be expensive and time consuming. When a Customer is considering Additive Manufacturing for the speed and cost benefits, the inspection requirements can often ruin a business case. Fortunately, Additive Manufacturing also provides additional data that conventional manufacturing processes do not, and this can be utilized to offset some of the conventional inspection needs.

Most Additive Manufacturing equipment today generates some kind of data prior to the build, during calibration and setup, during the build, and after the build. This data can come in the form of text, csv, image, or PDF files depending on the platform being utilized for production. The challenging question is what does a Producer do with all the data? First and foremost a robust data collection and storage system needs to be in place. This ensures all data is captured and can be correlated back to the specific build and possibly specific part within a build. Once the data is collected there are a handful of tools available to analyze the data in a meaningful way.

Figure 2: In process image from Electron Beam Melting machine

Statistical analysis software that can analyze large data sets and identify correlations can be extremely useful and save the Producer a lot of time and effort. Many companies

are also developing their own analysis software specific to Additive Manufacturing technologies. At this point you have a lot of data, some analysis has been done on that data, but how can you use this to ensure consistent quality as well as save time and money?

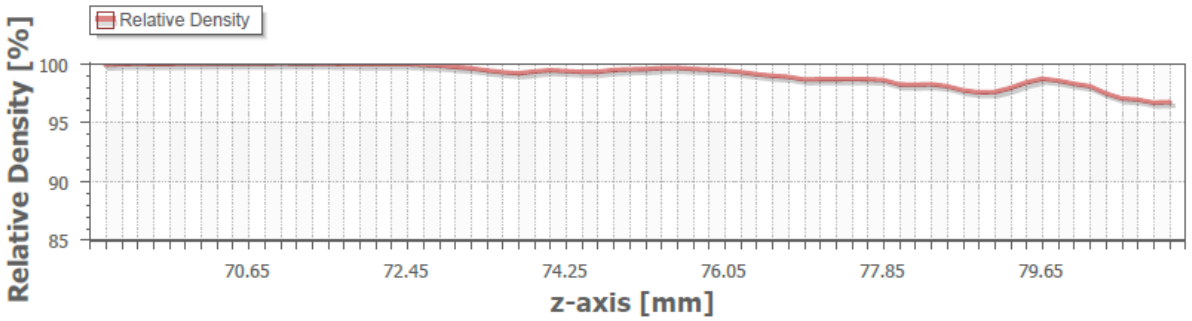

Figure 3: Example analysis of in process data

Key Process Variables are those characteristics of the process that have a direct impact on the quality of the part being produced. A Producer must combine the information received through conventional inspection techniques with the output from the in-process data analysis to find correlations and identify which characteristics are Key Process Variables (KPV). Once this is done the Producer can establish allowable values and tolerances for each KPV and being to employ statistical process control (SPC). SPC can be applied in a variety of manners, but the most useful application initially will be control charts. A Producer can maintain control charts with identified limits for each KPV to demonstrate that their process is consistently meeting the requirements.

Now that the Producer has control over their fixed process through their PCD, a robust data management system in place, has identified the KPVs, and is maintaining control charts around those KPVs, they will be able to use Additive Manufacturing to produce critical parts with consistent quality.

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