WEBINAR FAQs

Thank you for joining our webinar “Materials Engineering in Additive: From Powder to Production”. We had a lot of great questions but unfortunately, didn’t have time during the webinar to get to them all. So, below is an extract of frequently asked questions.

1. **What is the relationship between powder size and layer thickness for laser powder bed fusion (LPBF) and electron beam powder bed fusion (EBPBF) technologies?**

Typical powder size distributions for laser powder bed fusion (LPBF) machines range from 10 – 20 microns for the lower limit, and 45 – 63 microns for the upper limit (e.g., 10-45, 15-63, etc.). Layer sizes typically range from 30 to 60 microns.

It would be most common to have your layer thickness be either just larger than or very close to the upper limit of the particle size distribution, but that isn’t a requirement. That is, we could build parts out of a particle size distribution of 45 – 106 microns, but only have layers that are 50 microns thick.

In fact, this is exactly the setup for our Q10plus electron beam melting (EBM) machines using Ti6Al4V. The reason this is possible is that particles are not packed 100% dense in the powder bed; think about the negative space in a box full of basketballs. When we melt the powder, all those negative spaces fill in, so when more (big) powder particles are swept across the top layer (recoated), they have a place to go.

The choice of particle size distribution is multi-faceted, and the GE Additive Materials and Process team regularly guides our customers to make the best selection for their application.

2. **Are fatigue life (S-N) curves the same across all additive materials?**

Just as we can’t expect a single material (Alloy 718, for instance) to have identical S-N curves for its forged and cast versions, we similarly cannot expect additive 718 to be identical to either manufacturing method.

This is part of the classical “material-process-properties” relationship. When changing the “process” portion of that triangle, we have to expect the “properties” to change as well. Additionally, one can expect different materials to have different S-N curves.

Generally speaking, different materials will inherently have different fatigue life capabilities. To further complicate matters, the fatigue capability of some materials is significantly impacted when exposed to high temperature or stress concentrations, like notches.

3. What is the source of gas porosity in the electron beam melting (EBM) process, knowing that the build happens in vacuum?

Gas porosity is typically introduced via the powder. Occasionally, powder can form a "shell" around a pocket of gas used to atomize that powder. When that's the case, this porosity can be carried over into the final solid part after additive manufacturing due to the solidification kinetics being faster than that of the gas leaving the powder particle.
More commonly, the gas does escape, and the final part retains that pore due to local solidification happening very quickly.

That is, the metal freezes before it can flow into the void. The benefit in this case is that voids in electron beam melting (EBM) are full of nothing (i.e., vacuum) and can be closed quite readily during hot isostatic pressing operations.

4. Is hot isostatic pressing (HIP) required for every additive component?

No, hot isostatic pressing (HIP) is not required for every application.

HIP employs a combination of high temperature and high pressure to eliminate macro and micro internal pores, which can improve mechanical properties in additively manufactured components.

The decision to HIP as part of the overall thermal processing cycle typically relies on the mechanical property requirements of the component and/or any requirements set by any regulatory bodies, if applicable.

In many cases, if the density, microstructure, and mechanical properties without HIP meet the internal design requirements for the part, then the HIP step can be excluded. This relies on the additive manufacturing user characterizing the material behavior after all desired thermal processing to ensure they exceed their part design requirements and, where applicable, agreement from their regulatory body.

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5. What is the reason for characterizing powder morphology for additive applications?

Powder morphology describes the shape of the individual powder particles, which is highly dependent on the technique used to produce the powder particles (gas atomized, water atomized, plasma atomized, electrolytic, crushed, etc.).

Some techniques may result in more spherical particles, while others with more irregular or oblong particles, while some with more needle-like or acicular-shaped particles. Even within a particular atomization technique (e.g. gas atomized), some powders may have a tendency to agglomerate or contain ultra-fine particles (satellites) attached to the surfaces of larger particles.

All of these factors have an effect on powder packing density and the ability for the powder to flow and be spread evenly across the build plate, which, in turn, can have a significant influence on the melting behavior and, consequently, the final as-built part density.

6. Do you have any tips to successfully print large parts?

Printing large parts successfully depends largely on thermal management. For laser powder bed fusion (LPBF) platforms, one can expect to see thermal distortion across the platform as part size increases.

Part orientation, support strategy, and geometry compensation (where necessary) are key to address this distortion.

Part orientation plays a major role in how thermal stresses develop. Generally, the desire is to keep a relatively consistent cross-sectional area for the entire Z-height of the build, so that the thermal loading is consistent.

Additionally, we use build supports to not only support overhang surfaces, but also to manage thermal conduction and part distortion. If both orientation and supports have been optimized and part tolerances are still not being met, the CAD model can be modified such that when the part distorts it falls into the original desired shape. Employing these methods will greatly increase the chance of success for large parts.

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7. What contributes to machine to machine variation, and how does this variation affect part qualification?

Machine to machine variation can come from multiple sources. Laser powder bed fusion (LPBF) and electron beam melting powder bed fusion (EBPBF) machines go through extensive optics and beam calibrations to ensure the beam settings are being executed properly.

Because the laser or electron beam movements are very small and therefore have to be precise, there will inherently be slight differences that could manifest themselves in beam quality.

When qualifying production parts, GE Additive recommends first qualifying each individual machine with the desired material to ensure the machine is operating as expected, and then qualifying each part number on each machine. This ensures that the part-specific requirements can be met on each machine intended for production.

8. How does the heat treatment of additively manufactured parts differ from that of parts made through traditional manufacturing methods?

Typically, parts made through laser powder bed fusion (LPBF) go through a stress relief process, which would be the same as a post-machining stress relief heat treat. From there, all the steps would be the same a traditionally manufactured part.

Electron beam powder bed fusion (EBPBF) requires the whole powder bed to be sintered at relatively high temperatures, meaning there are fewer residual stresses inherent to the process. Therefore, stress relief heat treat is not necessary for EBPBF, and parts would simply follow the recommended thermal cycles for traditionally manufactured components. The binder jet process has additional binder burn-out and sintering steps before final heat treat.

9. What is skywriting?

Skywriting is a laser scan strategy that is employed to improve the accuracy of laser start and stop points.

In order to adjust laser scan path direction, the scanner will move mirrors to change the angle of the laser beam. When building corners where the laser path takes a significant change in direction, corners tend to swell due to increased laser dwell time or become rounded due to mirror momentum. Skywriting is a technique that reduces laser dwell time by turning off the laser power as it moves around sharp corners.

10. Can we increase productivity by adding additional lasers and not compromise on surface quality?

The addition of multiple lasers to build a single part is a great way to increase productivity.

However, there will always be some level of surface indication where the two lasers overlap, or “stitch” the part together. The magnitude of surface indication is largely dependent upon laser calibration. If the lasers are well calibrated and aligned to one another, the stitch line will be much less visible.