7 Questions Manufacturing Professionals Must Ask

Before Buying a Metal Additive Manufacturing Machine

A white paper for manufacturing executives and technical leaders exploring metal additive manufacturing technologies.

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Executive Summary

Additive Manufacturing of metal parts (Metal 3D Printing) is a game changer. The technology is seeing explosive growth and acceptance across industries. Business leaders are scrambling to implement and leverage this revolution for competitive advantage. Staying current with this wave of change is a strategic imperative for US manufacturers. The advantages over traditional manufacturing methods must not be ignored.

This white paper highlights critical factors you must consider when investing in additive manufacturing technology. Ask these questions to help select an equipment supplier and partner that best fits your unique business needs.

If you:

1. Understand the benefits of Additive Manufacturing and where it fits in your business*
2. Are comparing specs, features, and business policies of competing suppliers
3. Have concerns about making the right decisions for the long term

<u>This document is for you</u>

*If you are just starting your exploration of this technology, these questions might be a bit early for you. It may make sense to focus on the basic business case before making comparisons. If you need help with these basic business issues – ask!

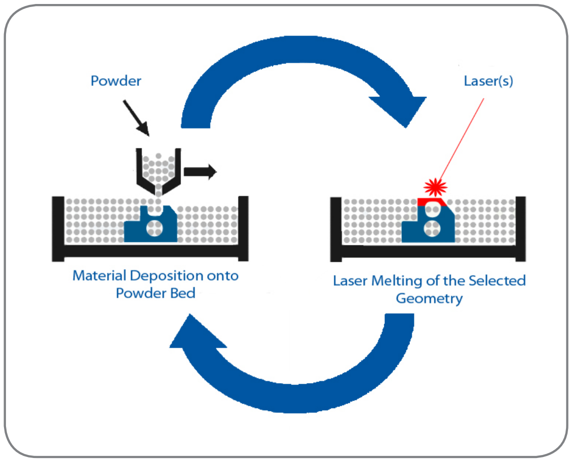
1. What is the difference between processes?

Making sense of the additive manufacturing "alphabet soup" (and exposing our industry's dirty little secret):

AM, 3DP, DMLS, SLM, DMLM, SLS….. OMG?

The Additive Manufacturing (AM) world loves acronyms. We won't even *try* to tackle them all in this brief overview. Instead we'll focus on the most common acronyms related to addtive metal processes.

The vast majority of metal printers in use today are based on Powder Bed Fusion Technology. A layer of fine metal powder is spread across a machine bed. The selected regions of the powder layer are then fused to the layer beneath them. The process repeats layer by layer until the entire part is built within the powder bed. Unmelted powder is removed to reveal the finished parts on the build plate.



The melting is typically done with a high power laser.

With that background, here is some industry insider insight...

Common trademarked acronyms you will come across include Direct Metal Laser Sintering (DMLS), Selective Laser Melting (SLM), Direct Metal Laser Melting (DMLM), and Laser Cusing. Here's the secret: on today's systems they all refer to the ***same*** process. Competing equipment suppliers use the same lasers and the same basic melting process, the only difference is the marketing behind the name.

WAIT! - WHAT??

Wait a minute you may be asking yourself. If the industry competitors use the same lasers and same technology, how do I compare them? What do I look for? What questions should I ask?

Now things get interesting. In fact there are major differences in how machines are designed and operated. Differences that can accelerate (or hinder) your efforts to gain an edge on your competition.

The questions raised on the following pages provide a good starting point!

2. What are my safety concerns?

Safety concerns fall into two main categories – powder handling during operation and maintenance operations.

First of all, the powders used in this process are *very* fine and can contain particles as small as six microns. These are hazardous to breathe so operators must use proper safety gear, or personal protection equipment (PPE) whenever they are exposed to metal powders.

PPE is a start, but it can be improved greatly through system design features that minimize exposure to metal powder. Review the recommended sequences for loading and recovering powder and see how many points of concern exist.

Another important area of safety concern is maintenance of the filtration system. The AM process generates particles and smoke that are filtered to keep the process running smoothly. Periodically, the filters must be changed. Understand fully the steps of this process for the equipment you are considering.

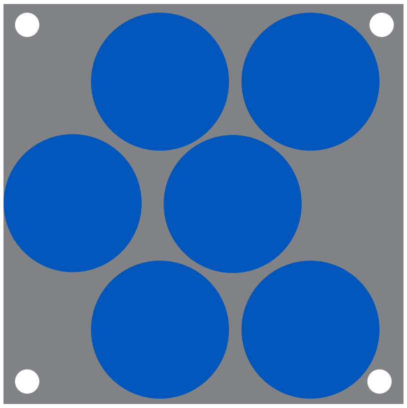
Some designs will expose your operators to dangerous particles in the filtration system. Other designs allow safe handling and passivation (neutralization) of harmful content in a sealed environment.

NOTE: If you are considering use of reactive materials such as aluminum or titanium, powder handling concerns are amplified by a potential danger of fire or explosion. This is a real concern that many companies could overlook - don't make this critical oversight.

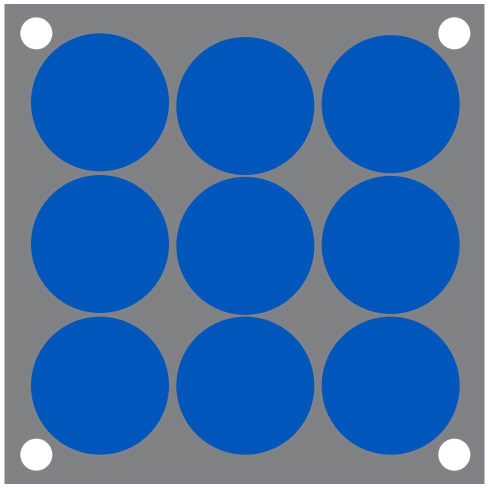
Why take chances? Look for a design approach the keeps your operators and facilities as safe as possible.

3. Does one size really fit all?

Build Envelope
The industry standard machine size for laser based powder bed fusion machines has historically been a 250mm x 250mm platform with a build height of 250-300mm. This size has stuck around for most suppliers – but not all. Read the specs and understand the difference that a "slightly" larger envelope can get you.



250 x 250 mm build plate



280 x 280 mm: 22% larger build plate fits more, as well as larger parts

System Configuration Options
You can have any configuration you want… As long as it's "the standard configuration." That may not be the answer you are looking for – but that may be the only thing available.

In an effort to keep things simple, many suppliers have a "one size fits all" approach. That may meets your needs today, but be sure to think about this in both the short and long term.

Some factors you should consider are:

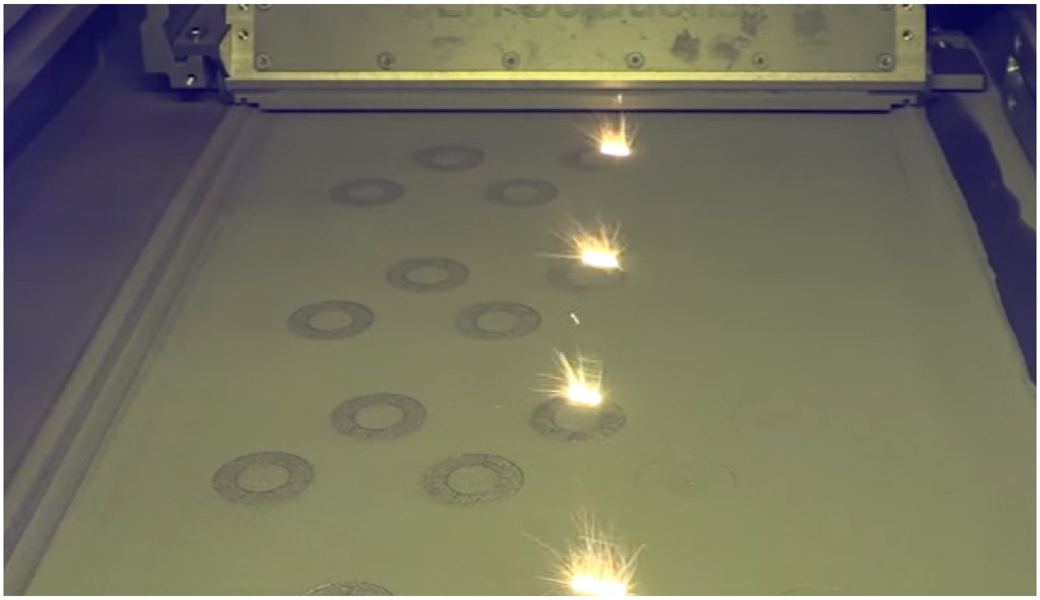
1. How frequently will I be changing materials? Is this easy or difficult?
2. Are there times when I would like to run small sample tests –with potentially expensive materials? Is there a way to limit the material required without going to a smaller overall platform?
3. Do I have options for the material used in the recoater blade? (This is an area to explore if fine details and high throughput are important to you)
4. Will I be building large parts that use the entire build envelope? Is there a way to add more powder if supplies run low during a build?

4. How can I get there faster?

There are many factors to consider around the concept of getting "faster" results from additive metal processes. The time it takes to build a single part is probably the most typical reference point for comparing machines. This is a logical and useful number, but other factors will also have an impact on overall system throughput.

As you move from single part runs to low volume production or larger batches you should think through the following points and scenarios:

- How is powder coated on the build tray? Depending on system design, powder can be spread in both directions or only in one direction. Feeding powder in both directions can save hours of production time. A single build can contain 10,000 layers and "wasted" seconds on each layer add up quickly.
- What options are offered for laser configuration? Lasers are the heart of the system, so if you have more lasers, you can produce more parts – *faster*.
- How is material fed to the build chamber? Is the supply continuous or fed from an initial batch of material? Batch fed systems can require the machine to be interrupted to refill supplies during a run, which slows down the process.
- All mechanical systems are going to have operating issues from time to time. Can the system you are looking at recover from minor errors without operator intervention?
- Are you able to "tune" system operating parameters to increase speed? (more about this issue on the next page)



Multiple lasers contibute to increased throughput. Here, four lasers work simultaneously across the build plate to maximize build speeds.

5. Who owns my operating parameters?

Proper operating parameters are the key to building successful parts.

Many factors, including but not limited to laser power, scan speed, stripe width and focus settings are developed for each material and each machine. These parameters ensure acceptable quality over a range of part geometries. This development is not a trivial process – and rarely an exercise for "beginners".

As users move up the learning curve, however, some tweaks to baseline parameters are useful (or needed) to optimize build results. A short list of factors you may wish to optimize for include:

- Build speed
- Surface finish
- Porosity
- Specific metallurgical properties

To modify parameters, you first need to have an understanding of what the baseline parameters are. Secondly, you will need a set of tools to make the trial and error process as easy as possible. This may sound straightforward, but you will be surprised to find that it is not always the case. This aspect of system design is where suppliers vary widely on business policies and the tools provided.

In some cases, parameter sets must be purchased for each individual material. These parameters may be locked to prevent any editing by the user. Parameters may even carry annual licensing fees. Other suppliers offer an open architecture for parameters, along with robust tools to help your development efforts.

Make sure to understand the policy and feature sets around these parameters fully before committing to any supplier.

⊟ Volume offset hatch	
Speed	550 mm/s
Power output	100 W
Focus offset	0.5 mm
Point distance	1 µm
Point exposure time	1 µs
⊟ Skin area	
Speed	710 mm/s
Power output	175 W
Focus offset	2 mm
Point distance	1 µm
Point exposure time	1 µs
⊟ Volume area extra	
Speed	1 mm/s
Power output	0 W
Focus offset	0.2 mm
Point distance	200 µm
Point exposure time	400 µs

Sample selection of typical operating parameters

Is this new technology an area where you can gain competitive advantage in your market? If so, parameter development and introduction of exciting new materials may be critical to your success. Like any piece of production equipment, the biggest gains will go to the user who invests the time and energy to understand their equipment and how to optimize performance for a competitive edge.

6. What if I want to try new materials?

As a new user, the most common approach to ramp up quickly is to use materials and parameters supplied by your equipment supplier. This removes variables and speeds up the learning curve dramatically. As you gain experience you may want to explore new options.

Material companies are making huge investments to develop new material variants specifically for the additive market. As you look to the future, it may make sense to know that you have the flexibility to seek new avenues.

This issue is rooted more in business policy than technology.

Be sure to discuss this issue with potential suppliers. Will they support your efforts by openly sharing experiences? Or will their business practices slow your efforts?

This issue is closely tied to operating parameters. If you are going to explore new materials, you will almost certainly be developing and enhancing operating parameters. There are advantages in a single source of supply for all aspects of operations (machine, materials and software parameters). However, in a manufacturing environment a "me too" strategy rarely creates a sustainable competitive advantage.

Why take chances? Look for a design approach the keeps your operators and facilities as safe as possible.

7. What are the "hidden" operating costs?

Additive metal machines have operating costs. These vary as a result of system design as well as business policies. The most important factors are typically:

1. Raw materials: as stated in question 6, it may be important to have choices for where you purchase materials. This will impact quality, differentiation in the market and, of course, cost.
2. Inert gas: the additive build process requires an inert, oxygen free environment. This environment is maintained by a recirculated flow of argon or nitrogen. The amount of gas required is a significant consideration. Usage can vary by as much as 10x between suppliers – amounting to tens (or *hundreds*) of thousands of dollars annually.
3. Annual license fees: knowing the fee, if any, for use of operating parameters on each material you operate with.

Other cost items such as electrical power used will be fairly constant between suppliers (after all, they all use the same lasers!)

Conclusion

We hope the points raised here help you better understand some of the important choices you will have to make. Although most suppliers use similar core technology, system design and business policies vary widely. The decisions you make will impact your business for years to come as the additive metal field will continue to expand and change.

About SLM Solutions

SLM Solutions is a leading provider of metal-based 3D additive technology and machinery for prototypes and manufacturing production. SLM Machines support an optimal approach for safe, flexible and cost efficient metal part production across the aerospace, automotive, academia, energy and medical industries. Systems include the SLM 125, SLM 280 and SLM 500. With multi-laser options, bi-directional recoating, open-software controls and closed-loop powder handling, Selective Laser Melting systems achieve best-in-class safety and increased build speeds for complex and completely dense metal parts.

Headquartered in Lübeck, Germany, SLM Solutions Group is a publicly traded company (TecDax AM3D.DE) with its North American offices located in Metro-Detroit. SLM Solutions NA, Inc. offers full support for local customers featuring a development lab, application engineering team, PhD. metallurgist and service engineers located around the county.

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