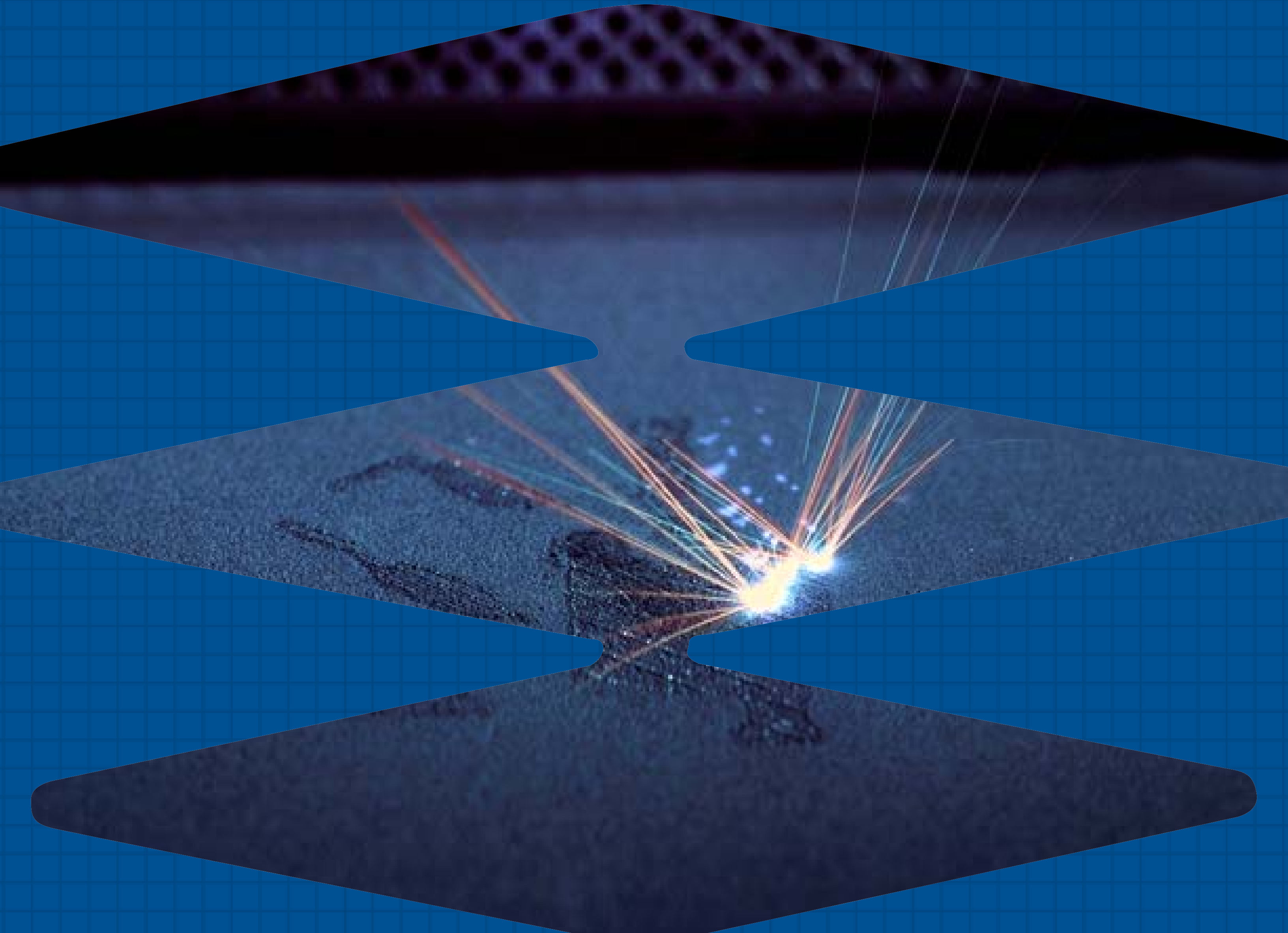
Additive Manufacturing 101

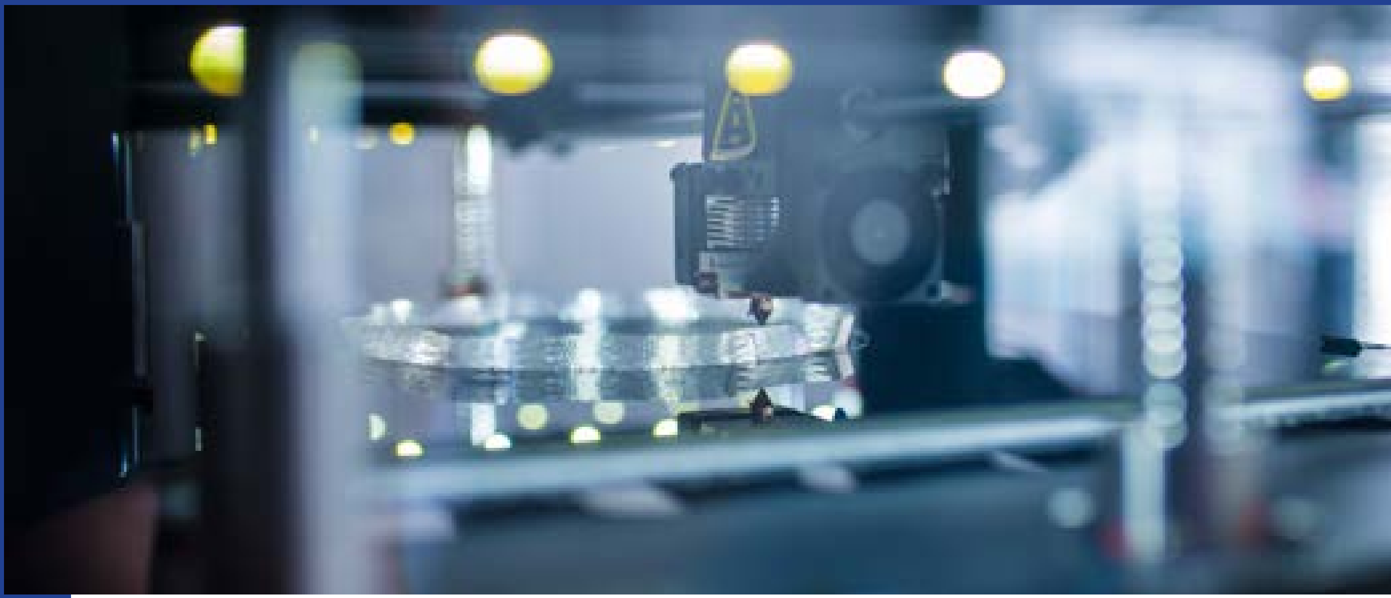
Your Guide to Getting Started with Industrial 3D Printing



Executive Summary

Many manufacturers want to jump into the world of additive manufacturing but don't know where to start. In this guide, we cover the following:

After reading, you will possess the information you need to feel confident about additive and know exactly how it can enhance your business.



A Brief History of Additive

Additive manufacturing, also known as industrial 3D printing, has been at the forefront of innovation in the manufacturing space for decades. The aerospace industry has a long history with additive, being an early adopter, trailblazer, and innovator. They set the standards and practices of additive manufacturing across most industries. While additive manufacturing has been primarily used to create prototypes for testing and quality assurance, aerospace innovators are now embracing additive manufacturing beyond prototyping to pursue new applications of the technology. Additive manufacturing is helping aerospace manufacturers become more cost-effective, agile, and efficient in bringing new products to market while remaining at the forefront of innovation.

Today's additive manufacturing technology takes 3D printing from a prototyping tool to a viable means of full production. It produces exceptionally high-performance parts from aluminum, titanium, steel, and nickel alloys with complex geometries for critical parts. In many cases, additive manufacturing can produce cost-efficient parts faster than traditional machining.

Types of Additive Manufacturing Technologies

Selecting the right additive manufacturing method is critical to producing viable parts that function well in the field. This section will explain the main processes used in AM today and their advantages and disadvantages.

Direct Metal Laser Sintering (DMLS)

Instead of using a liquid binder like MBJ, DMLS uses a laser to melt the metal powder particles, fusing them layer by layer.

Advantages

- Reproducible, defined part properties
- High part strength
- Design flexibility with the ability to produce highly complex parts

Disadvantages

- High(er) machine investment
- Thermal distortion risk (proper heat treatment is key)

Applications

- Injection and blow molding tooling
- Metal prototypes
- Press tools
- Defense and military technologies
- Commercial aerospace components
- Automotive parts
- Light weighing for aviation
- EV
- And many more

Laser Powder Bed Fusion (LPBF)

Using a high power-density laser, metal powder is melted and fused to create the final part. LPBF produces fully dense, durable metal parts that work as both functional prototypes or end-use production parts.

Advantages

- Produces strong parts
- High levels of complexity are possible

Disadvantages

- High power usage
- Thermal distortion can shrink/warp parts

Applications

- Military technologies
- Commercial aerospace components
- Automotive parts

Metal Binder Jetting (MBJ)

In this process, a liquid binder is selectively applied to join powder particles layer by layer. After the part is printed, it requires post-processing such as sintering and infiltration to strengthen it.

Advantages

- Fast, green part production process
- Low-cost production
- Low to medium batch production

Disadvantages

- Complex parts with varying structures are not possible, oven process for sintering is needed
- Weaker mechanical properties
- Only produce prints with rough details

Applications

- Non-structural metal parts
- High volume, low-cost components

Electron Beam Melting (EBM)

Unlike LPBF, EBM uses an electron beam to fuse metal particles together and create the desired part layer by layer.

Advantages

- Reproducible, defined part properties
- Creates complex and highly resistant parts
- Fast manufacturing speed

Disadvantages

- High(er) machine investment
- Expensive evacuating of process chamber needed
- Less precise

Applications

- Implant design
- Engine parts

Hybrid Metal 3D Printing

Is the combination of 3D printing and traditional manufacturing in a single machine to streamline the process of machining and finishing.

Laser Metal Melting + High-Speed Milling

- Create finished 3D printed molds with a single machine by shortening lead times, streamlining mold design and reducing the components needed to create a complete mold.

Selective Laser Melting + Stress Relief + Shaping

- Endless possibilities are in this one powerful machine that combines metal 3D printing, heat treatment, and shaping into a single cycle. Reduce warpage and prevent cracking while working more easily with carbon-containing materials and reducing post-processing time.

Materials

Both metal powders and polymers can be used in additive manufacturing, and each material has different properties and applications in the manufacturing industry.

Metals

Aluminium alloys for printing such as those from EOS are lightweight without sacrificing strength. Parts made with additive manufacturing using aluminum typically have a textured, matte surface, distinguishing them from traditional milled aluminum parts. Due to its low weight, 3D-printed aluminum is used for automotive and racing parts.

Cobalt Chrome is corrosion-resistant, nickel-free, and durable at elevated temperatures. It is best used when nickel-free components are required, such as in orthopedic and dental applications. Cobalt chrome is often used to print parts that benefit from hot isostatic pressing (HIP) to strengthen grain structures, producing fully dense metal parts.

Precious Metals are used most in jewelry industries, dental, electronics, and more. Unique and beautiful pieces of jewelry feature interlocking or interwoven designs that are only possible with additive manufacturing.

Tool Steel is heat treatable with superior hardness, strength, and deformation resistance. They maintain a sharp cutting edge and are most commonly used in making tools and molds for injection molding applications.

Stainless Steel is corrosion-resistant, rugged, and malleable. It produces dense, super strong parts for extreme environments like jet engines and rockets while also providing the resistance needed to produce surgical instruments.

Titanium is light with superior strength, corrosion resistance, and biocompatibility. It is used to create various industrial parts, aerospace components, and orthopedic prostheses and implants.

Copper holds a high purity with good electrical and thermal conductivity. While difficult to work with, copper alloys are excellent for induction coils, rocket components, and electronics applications.

Nickel Alloys offer tensile, creep, and rupture strength with heat and corrosion resistance. These alloys are often used in high-stress, high-temperature aeronautical, petrochemical and auto racing environments.

Case Hardening Steel is wear-resistant due to high surface hardness after heat treatment. This helps in machining parts even after they are printed, and as a result, case hardening steel is used for series-production parts, tooling, and aerospace industry applications.

Polymers

PAEK (Polyaryletherketones) are chemical compounds with ether and ketone groups. Compared to other plastics, they have very high glass transition and melting temperatures, which is why they are used in high-temperature applications. Thanks to their long service life, PAEK polymers are often used to make high-performance molded parts in industrial contexts (bearing cages, gearwheels, impellers, etc.).

PA 11 (Polyamide 11), also known as nylon, is made from 100% renewable castor beans. It is chemical and mechanically heat-resistant and is ideally suited for highly technical applications thanks to its durability. PA 11 is ideally suited for producing functional elements that require high material strength and/or impact resistance (interior of vehicles, etc.).

PA 12 (Polyamide 12) powder is also known as nylon and is the most tested material for additive manufacturing. Parts made from nylon are robust, stable for long periods of time, chemically resistant and extremely versatile. This cost-efficient, general-purpose material is suitable for functional prototypes and qualified series production parts from the industry.

TPE (Thermoplastic Elastomers) have similar properties to elastomers—they are flexible at room temperature but remain dimensionally stable. When heated, they can be plastically deformed and processed like thermoplastics. Because they are easy to process, they can be used to replace cross-linked elastomers and soft PVC. TPEs can be used to make damping elements, bumpers, bellows, soles, handles, and hoses.

PP (Polypropylene) is the second most important type of plastic, accounting for nearly 20% of the global production of plastic parts. It is similar to polyethylene, but its material properties make it much harder, stronger, and more thermally stable. In industrial 3D printing, PP is used for functional prototypes that must be exposed to mechanical and chemical loads. It can also be used to manufacture parts that contain liquids, thanks to its chemical stability and low water absorption.

The additive manufacturing market is expected to double in size, from **$16B worldwide in 2022 to $33B in 2024**[1]

1. https://wohlersassociates.com/resource/wohlers-report-2022-finds-strong-industry-wide-growth/

Is Additive Manufacturing Cost-Effective?

Additive manufacturing allows for the profitable production of individual pieces in small and medium batches. Production is cost-efficient with 3D printing because of the faster time to market, reduced weight and assembly times, and the possibility of simple product mass-customizations. Compared to manufacturing processes such as milling, turning or casting, production costs for additive manufacturing are not dependent on how complex a component is. Before, expensive tools or specialized solutions were required, but with additive manufacturing, only a 3D printer and powder material are necessary. Additive is also the most sustainable option on the market. Instead of wasting materials or shipping parts in, you can print them in house and minimize scrap accumulation.

The Additive Process

- [ ] **1. Collaborate**
Create a team of additive champions dedicated to bringing your vision to life through additive manufacturing.

- [ ] **2. Design**
Start with part design. Invest in designing for additive manufacturing (DfAM) before investing in the technology to ensure you are taking full advantage of additive manufacturing.

- [ ] **3. Elevate**
Begin working with advanced CAD programs such as Siemens or Topology to take your traditional drawings and convert them into a 3D printing design.

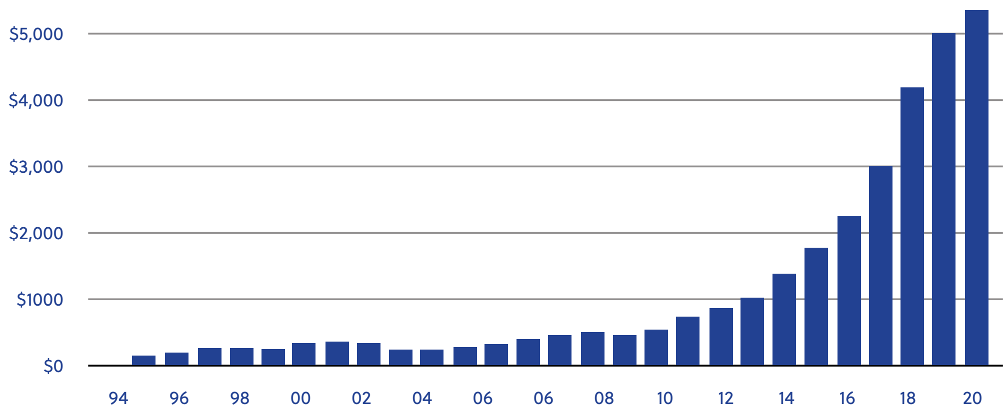
- [ ] **4. Invest**
Invest in the machine. Decide which machine you want to purchase, whether that is the LPBF or the hybrid solution.

- [ ] **5. Finish**
Select your post-processing. The heat treatment and finish machining could be an additional $150-200k if you don’t already have a machine to finish your parts.

Will Additive Manufacturing Replace Traditional Machining?

3D printing is becoming more commonplace in the world's largest industries. The uses and advancements within additive manufacturing are growing rapidly, and in many cases, this process makes more sense than traditional manufacturing. The short answer to this question is "sometimes." While there are a lot of benefits attached to additive, it's not the ideal approach to every project. For large build size and large volumes, EDM and other tried and true conventional methods are the better option. For more details, refer to this blog on Hartwig's website.

The additive manufacturing market grew **7.5%** through the pandemic and is on a steady incline.



Production of AM parts from independent service providers (in millions of dollars) Source: Wohlers Report 2021

Is Additive Right for My Operation?

Aerospace

Innovators have embraced additive manufacturing to fabricate jigs and fixtures, production tooling and end-use parts for intelligent and lightweight wing structures with high strength.

Medical

Companies that design and manufacture crucial life-saving technologies have turned to additive manufacturing to produce implants, medical models, external aids and prosthetics.

Automotive

Manufacturers have expanded from using 3D printing rapid prototyping to producing end-use vehicle components, cutting down the development and production costs.

Am I Ready for Additive?

Before you jump into additive manufacturing, here are a few key things to think about.

1. Look into products made by metal 3D printing, research how it can help your business, and watch videos about how additive has been used. Looking for a shortcut? Hartwig's resident additive manufacturing expert Jens Kautzor is always available to help you through the process.

2. Get connected with the Additive Minds Academy. Their specialized software and additive experts can help you identify the high potential parts you can create with metal 3D printing.

3. Create a business case. After beginning your work with the Additive Minds Academy, the experts will create a business case for you, providing more insight into how additive can enhance your process and your company.

Resources

Below is a list of resources available to learn more about additive manufacturing.

Sodick - 3D Printing

Sodick - Metal 3D Printing Products

EOS - Additive Manufacturing Consulting

EOS - Industrial 3D Printing

EOS - Advantages of Additive Manufacturing

Additive Manufacturing: How It Works

GET STARTED TODAY.

Additive manufacturing provides endless opportunities for innovation in your manufacturing processes. With design freedom, and flexibility in production time, volume, and location, you can set yourself apart from the competition with metal 3D printing. Find your Hartwig representative today and start your journey in additive manufacturing.

→ HartwigInc.com