Choosing the right manufacturing technique for a given application usually holds very few secrets, and comes naturally to most designers and engineers. For decades, they have had a palette of well-known metal manufacturing methods at their disposal: machining, casting, molding, welding, extrusion—every single one with its own strengths and weaknesses. Knowing when to choose an emerging technology like metal 3D Printing is far more challenging, and raises questions and uncertainty. When is it cost-effective? What is the added value? What about strength and quality?
Introduction

In order to fully benefit from the opportunities presented by 3D Printing, it is necessary to begin with a thorough understanding of the technology, the materials and the design process. A successfully printed metal part is always the result of a perfect interplay between those factors in function of the application. Some applications will benefit more from the opportunities than others, resulting in a significant improvement in terms of weight, performance, functionality and/or aesthetics. This paper aims to contribute further insights into which parts and applications are typically suitable for metal 3D Printing and for what reasons.

The Main Benefits of Metal 3D Printing

A. Design Freedom

In typical manufacturing, the product’s functionalities and appearance are a direct consequence of manufacturing process of choice. Metal 3D Printing however, by means of its layer-wise production, suffers from almost no manufacturability boundaries, especially in terms of geometrical freedom. This results in new and interesting opportunities for product design. The volume-based cost calculation of the part—as opposed to a complexity-based one—motivates designers and engineers to actively and economically explore more complex shapes, working towards the optimal functional design.

B. Production Speed & Costs

Unlike conventional production methods, 3D Printing requires no additional tooling during the production process. As a result, start-up time and costs are limited and independent of the batch size or the amount of design variations of one part. As a result, stock levels can be kept low and necessary design changes can be implemented quickly. This speeds up and optimizes the product development cycle and opens doors for customization and on-demand production.
8 Key Applications for Metal 3D Printing

1. Heat Sinks

Heat exchangers are designed to dissipate heat, for example, the heat generated by electronical and mechanical devices. The surface area highly influences the performance of the heat sink, but typically the available space is rather limited. That means maximizing the surface area within the dimensional boundaries is the key challenge.

The design freedom offered by metal 3D Printing allows for creating thin and complex geometries and lattice structures that make optimal use of the available space. Combined with the excellent thermal conductivity of 3D-printed aluminum, heat sinks are an especially well-suited application.

2. Spare Parts

The demand for spare parts is typically intermittent, and it is difficult to forecast when specific parts will be needed and where. Keeping those parts available on the shelves is a costly operation, requiring storage for the parts and retention of tools. Additive Manufacturing allows for on-demand and local production of spare parts, avoiding inventories and transforming entire supply chains.

To fully profit from the technology in terms of material usage, weight and functionality, a redesign is recommended. But as more companies adopt Additive Manufacturing for initial production, the management of spare parts will become simpler.

3. Structural Components

The fields of bionics and structural optimization show a great potential for industrial applications. Structures generated as a result of topology optimization often lead to highly complex shapes. By making use of the geometrical freedom that metal 3D Printing offers, these shapes can be realized with fewer manufacturing-related restrictions or adaptations.

Given the excellent mechanical properties of 3D-printed metal, this results in structural components that reduce the overall weight and material waste without compromising strength. This approach offers large possibilities in the design of structural components.
4. Tooling

In the tooling industry, the pressure on costs is high. Controlling those costs can be done partly by optimizing the part throughput of the machine and by reducing waste. One solution is the use of conformal cooling. By making tools through Additive Manufacturing, highly complex cooling channels can be integrated close to the part’s surface. This results in an optimized heat flow and time gains during cooldown, reducing the risk of warpage and improving part quality.

For parts which are so complex that conventional manufacturing methods would require labor-intensive and costly tools, direct production in Additive Manufacturing can be beneficial.

5. Medical Devices

Mass customization can be implemented sustainably only through 3D Printing, where design flexibility does not compromise cost-effectiveness. For this reason, the medical industry was one of the earliest adopters of Additive Manufacturing to make custom parts such as implants and personalized medical devices.

The bio-compatibility of printed titanium combined with the ability to create complex structures has opened new opportunities to minimize surgical impact, stimulate bone ingrowth, and improve a patient’s mobility. At that level of patient-specific customization, 3D Printing is the only technically feasible and cost-effective production method.

6. Food Processing

Food processing companies are often in need of custom-made parts. Making tools for these small series often raises production costs. The manufacturing cost of 3D Printing, which is not dependent on series volume, offers ways to keep costs down.

Additionally, the biocompatible nature of 3D-printed titanium allows for direct contact with foods and liquids. Combined with the design flexibility, this gives room for more functional and performant complex components used in gripping, feeding and depositing food products. By integrating functionality, the number of components can be kept lower, reducing the risk of downtime and the need for maintenance.
7. Fashion and Design

Attracted by the ability to design exceptional shapes and geometries, for both aesthetics and functionality, designers and artists have been experimenting with 3D Printing since the early days of the technology. With metal printing becoming more accessible, new doors open to create things that were previously unthinkable. Personalized jewelry, eyewear, design objects and accessories can be made in an ever-growing range of materials and finishes.

In a sector where brands require rapid design upgrades to maintain market competitiveness, Additive Manufacturing is a rewarding choice owing to profitable low-volume production runs and fast lead times.

8. Industrial Automation

Every project in industrial automation comes with its own requirements, calling for a custom solution. 3D Printing addresses this challenge through cost-effective production of small series and unrestricted design possibilities. Complex integrated functionality allows grippers and clamping devices to use fewer components and less manual assembly. Volume optimization results in a more lightweight and inexpensive gripper that allows robots to work at optimal speed.

The high strength and low weight of 3D-printed aluminum makes it a good fit for customized durable automation solutions, while stainless steel can be used for food-safe applications.

About Materialise Manufacturing

Materialise has been playing an active role in the field of Additive Manufacturing since 1990 and operates one of the largest and most comprehensive 3D printing facilities in the world. With its headquarters in Leuven, Belgium, and branches worldwide, Materialise is a provider of Additive Manufacturing software solutions and sophisticated 3D printing services in a wide variety of industries, including healthcare, automotive, aerospace, art and design and consumer products. At Materialise Manufacturing, we help designers and engineers develop better innovations through our rapid prototyping solutions and certified additive manufacturing processes for end-use parts in metals as well as plastics. Drawing from our 25 years of experience, we co-create new and meaningful applications with customers in a variety of industries, ranging from automotive and industrial equipment to aerospace and consumer goods.

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