the difference between

THE DIFFERENCE BETWEEN:

3D Printing and CNC Machining

With today's increase in complexity for engineered products and the need for faster production of these products, manufacturers are having to choose between technologies. This article will discuss and compare two of the methods used to produce parts, while recognizing that each has its place, and can complement each other in the design and manufacturing workflow.

SIMPLY PUT, 3D PRINTING is an additive process, while CNC machining is a subtractive process. CNC machines start with a block of solid material and use sharp rotating tools to remove material until the product shape designed is produced.

As an additive manufacturing process, there are several types of 3D printers that use different technologies and materials. Some systems build parts from fused layers of a thermoplastic material, some from layers of a photopolymer that is

cured by a light source, and others bind or sinter layers of powdered materials from starches to plastics or metals. All of them, though, build three-dimensional products one layer at a time.

Design Freedom

In general, CNC machining is still the go-to solution for products that need to be extremely strong and robust, and provide a high degree of heat and chemical resistance—products typically made of metals. Limitations of CNC machines include the initial costs involved in purchasing and maintaining the machines, the need for a trained operator, and the increased waste produced by the machine *(see Fig. 1).*

A 3D printer's most valuable benefit is that it does not have the same design limitations as a CNC machine. Because of its layered additive process, 3D printing is the only solution when manufacturing complex products that would be impossible or prohibitively expensive to machine—such as difficult undercuts, hollow parts, or organic shapes. 3D printers are used to produce parts in a range of applications, including vehicle dashboards, specialized end caps, and prototypes of all kinds. Modern 3D printing systems can even produce high-strength parts that rival machined products, like custom manufacturing tools and fixtures for end-use production *(see Fig. 2).*

1. CNC machines often require a dedicated, full-time operator, while 3D printers are mostly automated after the initial set-up.

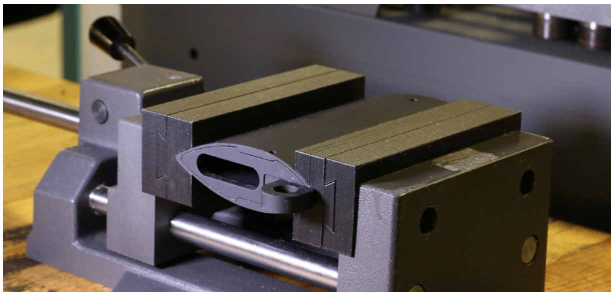
2. 3D printers can complement the machine shop by producing complex, high-strength manufacturing tools and fixtures.

Measuring Precision

After design freedom, one of the most important considerations when choosing between 3D printing and CNC machining for a specific application is precision, which includes system accuracy, repeatability, and resolution.

Well-built, modern CNC machines are capable of producing parts that are highly accurate. Tolerances for standard machining, measured in thousandths of an inch, are around ±0.005 inches. Fine machining centers can reach tolerances of ±0.001 inches. With specialized post processing, you can reach tolerances of ±0.00005 inches. Note that there are multiple ways to consider the tolerance of your design, including location, orientation, form, and profile. When checking a machine's capabilities, consider repeatability and resolution as well.

3D printers also deliver high precision in their layering process. Extrusion-based printing systems generally produce layer resolutions to ±0.005 inch with an overall tolerance of ±0.0015 to 0.0035. Because they print layer by layer and use a variety of materials, precision can fluctuate, making them less precise than CNC machines. Material properties, thermal deformation, and build speed can all affect precision. Higher quality industrial 3D printers can deliver precision that rivals CNC machined parts and at a lower cost per part.



3. 3D printed soft jaws are capable of producing strong, non-marring jaws at a fraction of the price of machined alternatives.

Material Selection

CNC machining is typically performed on materials such as aluminum, brass, copper, steel, stainless steel, tungsten, and other metals. Nonetheless, these machines can also be used on plastics such as PVC and Nylon 6/6. With the right tooling, CNC machines can work with almost any material.

Most 3D printers, on the other hand, have a limited number of materials they can use, which often include a variety of photopolymers or thermoplastics. While it is possible to 3D print parts in metal materials, these processes are relatively new and the machines can be expensive and unreliable.

For applications that need the tough, non-marring properties of thermoplastic combined with the robustness of aluminum, and want to maintain low costs, there are affordable machines with higher strength capabilities on the market. For example, the Markforged Mark Two and the X7 Industrial Composite 3D printers automatically lay continuous strands of fiber—carbon, Kevlar, or glass—during the printing process to deliver affordable parts with a high strength-to-weight ratio.

Messy Environment and Waste Production

The subtractive nature of CNC machines means that they generate a lot of waste material. This produces a lot of waste for cleanup by the operator, plus non-reusable scraps, so you pay for more material than you use. As a consumable, the cooling fluids used to maintain temperature during machining must be cleaned up after every job.

3D printing is a relatively clean operation from start to finish, with minimal or no waste whatsoever. Occasionally, structural scaffolding—used to support overhangs or cantilevered design elements during the printing process—are breakaway components and easily discarded.

Part Costs

The price per part incorporates a wide variety of factors, including material cost, tooling requirements, machine maintenance, and operator salary. Consider that in a subtractive process you are always buying more material than needed, always using consumables that must be cleaned up, and often need job-specific tooling and work-holding equipment like vices, parallels, soft jaws *(Fig. 3)*, and other tools. Let us not forget that you must employ a trained operator whose salary increases with skill level.

3D printers, on the other hand, are often much less expensive to buy, install, and maintain. Further, the machine operator for a 3D printer doesn't have to attend to the printer during operation. Other cost savings associated with 3D printers include lower material costs, less waste, and reduced power needs. These benefits reduce the overall cost per part when compared to that of CNC machining.

Conclusion

Most modern machine shops incorporate a number of 3D printers depending on the shop's applications to support business. Because 3D printers are fairly affordable, it is easy to use them for support jobs that can increase machine bandwidth. Applications most suited for 3D printing include prototypes, tooling and fixtures, and low-volume end-use parts.

Rather than have your most valuable employees and equipment focused on early prototypes, sanction your 3D printer for those jobs—especially if you may have multiple prototypes before a final design is selected.

Custom tooling and fixturing jobs for specific parts are necessary for any number of manufacturing operations or part quality inspections, and 3D printing these can also offload machine bandwidth. Additionally, every machine shop receives small projects that are not financially worth the time and equipment necessary for them. Such jobs include making custom tool racks, part delivery systems, barrier blocks, or part holders, and by 3D printing these types of components, machine shops won't need to interrupt larger-volume production runs for the sake of single parts. Overall, many machine shops see a fast return-on-investment from incorporating 3D printing tools into their capabilities to complement existing operations and decrease costs and lead times. ■