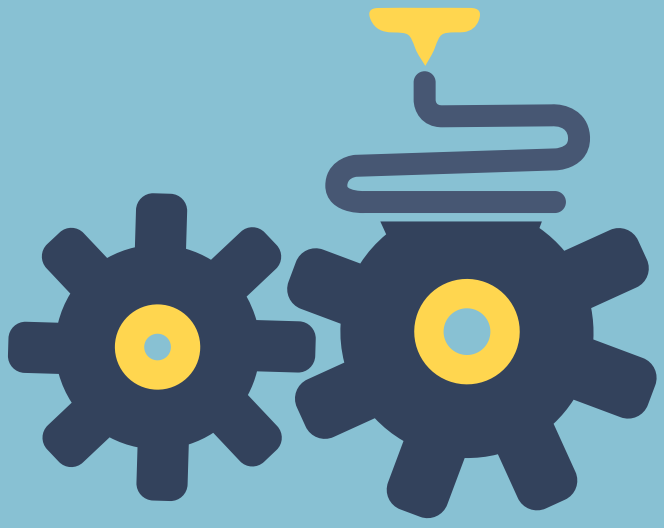
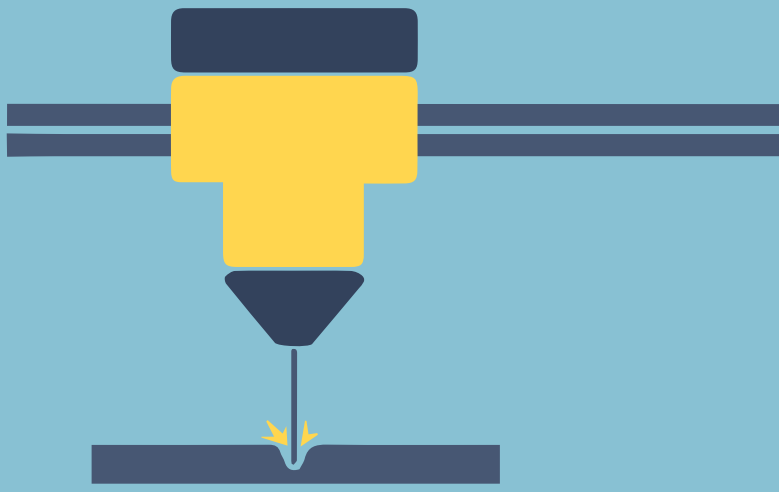
Additive

or

Subtractive





Prototyping:

Which is best?

PROTOMATIC

Life-saving precision.

Additive or subtractive prototyping: which is best?

The design is done. Now what?

Your design is complete and now it's time to take it to prototype. But what process should you choose?

There are two distinctive prototyping and manufacturing methods that are constantly being compared and evaluated when companies look to take their designs to manufacturing: subtractive and additive (3D printing).

As companies seek solutions that provide better, faster, more cost-effective ways to produce prototypes and manufacture parts, they find that both technologies have benefits and drawbacks, depending on the application and business criteria.

This book will provide explore the pluses and minuses and help you decide which process is best for you.

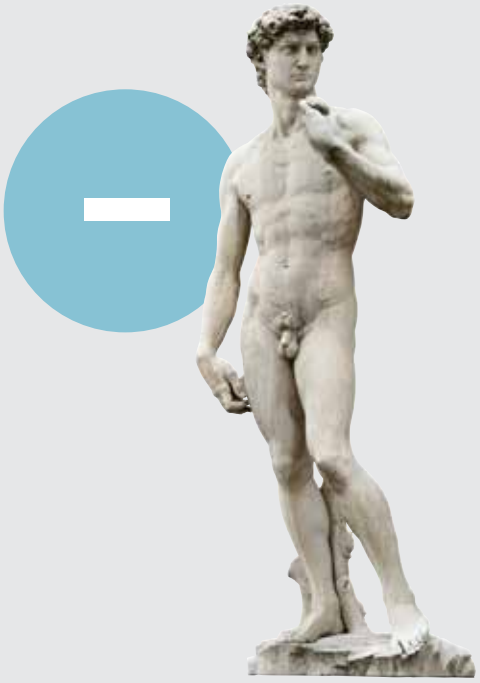
Additive or subtractive prototyping: which is best?

The basic difference

There are a multitude of pros and cons to consider when deciding between subtractive and additive (3D printing) manufacturing. Before we get into them, let's look at the fundamental difference between the two techniques: subtractive manufacturing involves cutting away what is not needed from larger pieces of the material; while additive manufacturing is characterized by assembling parts using only the materials you need.

When you get right down to it, it's kind of like comparing Michelangelo to Lego bricks.

Additive or subtractive prototyping: which is best?

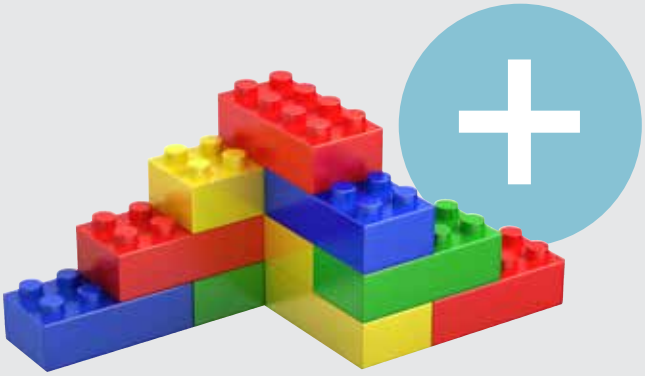


Michelangelo (Subtractive)

Think of subtractive in the same way that Michelangelo thought of a large chunk of marble. When asked how he created his masterpiece, David, he replied that he simply "chipped away all the stone that didn't look like David."

Essentially, that is how subtractive works. Subtractive methods include machining operations such as milling and turning laser cutting, wire EDM and carving. Undesired materials are removed to achieve the desired form. You subtract the material you don't want from the material you do want, until you're left with your product.

Additive or subtractive prototyping: which is best?



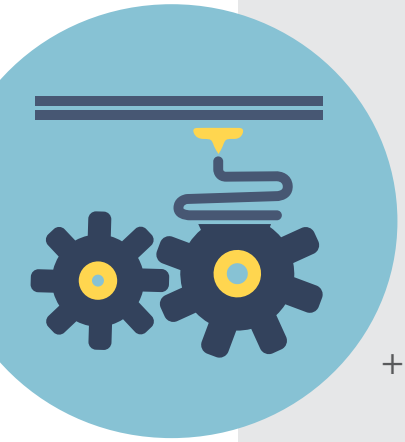
Building blocks (Additive)

Additive, or 3D printing, on the other hand, is like building something out of building blocks. You create a 3D model of your product, then layers of material are added on top of each other — like building blocks.

Here's another way to look at it. 3D printing works much like a desktop printer, but prints finished products. Instead of ink, a 3D printer uses a combination of basic elements that bond together as they are laid down, layer by layer. There is virtually no scrap because the molecular formations are added so precisely that the product appears in the exact shape desired.

Now, let's move onto the nitty-gritty.

Additive or subtractive prototyping: which is best?



Part complexity & function

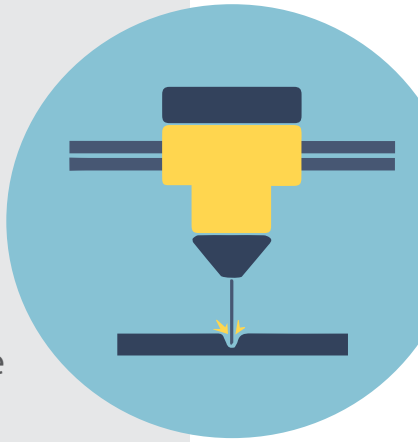
Additive (3D printing)

+ Can produce "impossible-to-machine" features, like "captured" components.
+ Additive manufacturing can produce a part in much less time than subtractive.
+ The more complex (less solid) a part is, the faster and cheaper it is to produce through additive manufacturing.
+ Complex geometry and organic shapes are often only possible to produce using additive manufacturing methods.
+ Moving parts can be printed directly into the product using additive manufacturing, which can significantly reduce the number of parts required.
+ Anything that can be designed in a CAD program can be printed with additive manufacturing.
+ Parts used for fit checks, presentation models and short-term use can best be made with additive manufacturing.
+ Hollow parts can be made in a single piece with additive manufacturing, but not with subtractive.

Parts complexity and function for subtractive follows on the next page

Additive or subtractive prototyping: which is best?

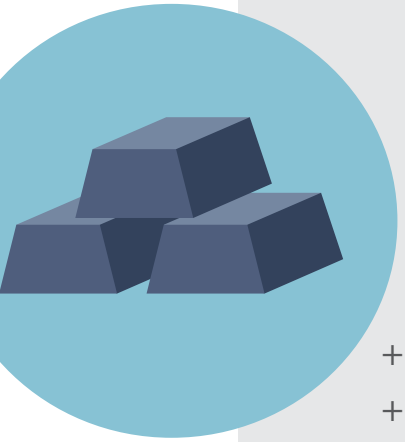
Part complexity & function



Subtractive

- Tolerances are lower (more capable) with subtractive manufacturing than with additive. Subtractive tolerances are +/- 0.002 inches; additive tolerances are +/- 0.007 inches.
- Subtractive manufacturing produces smoother surfaces (<Ra32uln) than additive (~Ra250uln or worse).
- When it comes to precision for common functional features, like flat faces, drilled and tapped holes, counterbores, and mating components, subtractive methods will generally produce results with the highest degree of repeatability and dimensional accuracy.
- Parts intended for long-term or high-stress use are best made with subtractive.
- Medical and aerospace industries prefer subtractive for parts required to stay in the body for extended periods of time and for flight-critical aerospace functions.
- Another advantage of subtractive is that additive manufacturing creates micro-pores. These can lead to infection in medical uses, and also add stress factors such as fatigue points that can lead to stress fractures with heavy loads.

Additive or subtractive prototyping: which is best?



Part materials

Additive (3D printing)

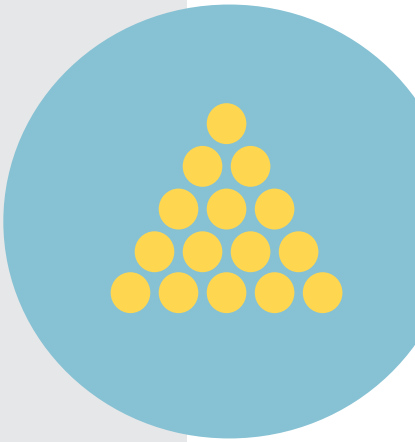
+ Almost always used in manufacturing parts from plastics.
+ Commonly used plastic materials include ABS, PLA, PVA, nylon and resins.
+ Ceramics and metals are being used on specialty machines, but at a high cost.
+ There is less waste because you only use the material you need.
+ Parts made for low-volume casting methods can use a 3D printed part to create a silicone mold used for casting a wide variety of materials.

Subtractive

– Better for engineering materials such as:
  - Aluminum and steel
  - Wood
  - Ceramics
  - Foams like polystyrene or structural foam
– Able to process multiple materials allowing R&D and engineering to prototype and experiment on end-production material resulting in real-world form-fit function.

Additive or subtractive prototyping: which is best?

Part quantity



Additive (3D printing)

+ Because of its speed and low unit cost at low volumes, additive is better when you need quantities of 1 – 10 parts.
+ Use for short-run production molds.
+ Can produce a complete set of different parts all during a single run.

Subtractive

– Large volume runs.
– Better for part-to-part repeatability, and when output of large numbers of the same part in a relatively short period of time is called for.

Additive or subtractive prototyping: which is best?

Cost

Additive (3D printing)

+ Time can be money, and a custom part can be created using additive manufacturing for a fraction of the time of other manufacturing processes.
+ Changes can happen quickly using additive manufacturing by revising the original CAD file and producing the part right away.

Subtractive

– At Protomatic, we've found that for 95% of the parts we make, subtractive is less expensive.
– If post machining is required, subtractive is less expensive than additive.

Additive or subtractive prototyping: which is best?

3 questions to ask yourself

After looking over the pros and cons of additive and subtractive manufacturing, you may still not be sure which way to go. This Q & A should be helpful.

1. What kind of features does your product have?

- Small organic and intricate features —— **additive methods**
- Large or sharp features, drilled and tapped holes, other fastening features ———————— **subtractive methods**

2. What type of material do you want to work with?

- Thermoplastics and resins ———— **additive methods**
- Materials like metals, wood or foam —— **subtractive methods**

3. How many units do you want to produce?

- Low-volume or iterative prototyping – **additive methods**
- Large volume production runs ——— **subtractive methods**

A final word

As you've seen, there are many variables that need to be taken into account when deciding between additive (3D printing) and subtractive manufacturing. It is always wise to consult with experts in the field, and get cost estimates on both techniques before proceeding.

Protomatic is a precision CNC manufacturer that embraces both additive and subtractive methods. We base our recommendations on which is best for our medical and aerospace customers' long and short term needs, then commit to life-saving precision throughout every step of the process.

We would be glad to answer any questions you might have about additive and subtractive manufacturing, and which would be best for your particular situation. Please contact our Managing Director, Doug Wetzel.

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