Various kinds of 3D printing technologies are making their way into the construction and manufacturing sectors. Most people are familiar with extrusion-style printing, but that isn’t the only option available. Powder bed fusion uses a laser to selectively melt the chosen powder into the shape of the desired item. From there, companies can reuse the remainder of the unfused powder once they remove the finished product from the fusion bed.

This type of 3D printing is beginning to take root in manufacturing industries. What are the pros and cons of powder bed fusion, and will this technology grow and evolve in the coming years?

1. Pro — variety of materials to choose from
Powder bed fusion isn’t limited to a single type of material like some other forms of additive manufacturing. Anything that can be turned into powder and melted into a new shape is possible to use in powder bed fusion, including metal, glass, ceramic, plastic, alloys and many other materials.

In one recent example, Skyrora, a Scottish space technology company, used powder bed fusion to create a rocket engine capable of 3 tons of thrust. It’s one of the largest such engines produced in the United Kingdom. The engine’s materials included Inconel, a trademark brand for nickel-chromium-based superalloys that resist oxidation and corrosion. Manufacturers often choose Inconel for parts that must tolerate extreme pressure and heat, and it shows you how both familiar and highly specific elements may suit powder bed fusion.

2. Con — slow print time
Unlike other types of metal manufacturing, especially when designing new parts, powder bed fusion can be incredibly slow. The process melts all of the individual particles together and, when you’re working with something like metal or ceramic that has a high melting point, it takes time for the finished piece to cool down.

Add to that the time it takes to preheat all of the powder in the printing bed, and the overall process is one of the slowest types of additive manufacturing available to you. One comparative study from Optomec contrasted the speeds of powder bed fusion and directed energy deposition. The latter technique relies on focused thermal energy to fuse the materials as they deposit.

Optomec found that directed energy was 10 times faster than powder bed fusion for printing mid-sized metal parts. While powder bed fusion took 240 hours to make a component in the investigation, the directed energy deposition option required only 18 hours.

3. Pro — little to no waste
Powder bed fusion utilizes a preheated bed of powder that’s targeted with a laser to create a final design. Once the project is complete, the unfused powder can be reclaimed and reused for new projects.

Unlike other forms of 3D printing, powder bed fusion has little to no waste. Extrusion printing, on the other hand, outputs a lot of excess material, especially if a print goes wrong, and you end up with a mess of molten plastic that doesn’t resemble the original project. Manufacturers spend around 30 to 50% of their time correcting such errors.

The company 6K, formerly Amastan Technologies, is even taking waste reduction further by creating the first additive manufacturing powders from sustainable sources. For example, the company’s process makes new powders from previously used ones, as well as certified machining turnings.

Concerning powder bed fusion, 6K’s CEO Dr. Aaron Bent noted, “…We can create new AM powders previously not possible: powders engineered from non-eutectic alloys such as high-entropy alloys, or designer aluminum alloys capable of printing in powder bed fusion systems.”
4. Con — requires lots of post processing
Manufacturers often use powder bed fusion to make metal parts, but a person must do several things to prepare the component for use. The first necessity is to remove the powder that buries the finished pieces. You can use powder bed fusion to create a variety of finely detailed items, but the completed exterior depends on the size of the individual granules.

Even small particles leave a sand-like texture on the surface. Capturing the used powder for later use is another step often taken, and it can be time-consuming.

Additionally, many parts made with powder bed fusion get heat treatments to enhance the mechanical properties and microstructure of each component. If an element has partially melted particles or other kinds of surface roughness, finishing is often another post-processing step undertaken to get the desired results. Also, the last step in post-processing is typically a careful inspection process. It’s particularly crucial if the component needs a part certification.

5. Pro — less need for additional support structures
Unlike other types of additive manufacturing, parts created with powder bed fusion may not need additional support structures. That’s because the powder acts as a kind of integrated formation, keeping the design secure until it’s cool, and you reclaim the unfused powder. The lack of additional structures helps companies use less overall material since, in many cases, these elements are single-use.

Although you don’t need to use supports for parts made with powder bed fusion, some people use them to safeguard against the warping and distortion that high temperatures can cause during the printing process. One of the primary advantages of not using support structures is that you do not need to spend the time to remove the structure and risk causing surface damage to or breaking the printed part.

However, researchers have successfully developed options for dissolving metal support structures used during powder bed fusion printing. The team concluded that their approach saves time and money. It's worth keeping an eye on developments such as this one, especially if the powder bed fusion projects you do sometimes require support structures for the best results.

6. Con — uses lots of energy
For manufacturers concerned with energy usage and creating a sustainable factory, powder bed fusion may not be the best option currently available. The lasers used to fuse the powdered materials, whether on a CO2 or electron system, consume a lot of energy.

The power necessary to generate a constant laser is essential to the success of this type of additive manufacturing. However, it will run up the facility’s electricity bills unless the company offsets the utility usage. One possible way to deal with the excessive energy costs can be to scale up production and create larger parts through powder bed fusion techniques that are faster than the conventional ones most often used today.

ADDere is a company working on that approach. It successfully printed metal blocks measuring $15 \times 15 \times 30$ centimeters and weighing up to 55 kilograms. Each one only took six hours to develop. Although powder bed fusion printing is energy-intensive, ADDere’s achievement shows that printing large pieces in shorter timeframes is an objective within reach and using the technology that way could be energy-saving in the long run.

7. The future of powder bed fusion
With these apparent pros and cons, what will powder bed fusion and other forms of additive manufacturing look like in the coming years? The field started as a way for hobbyists to create things they imagined. Nevertheless, it’s become a new way to fashion items for nearly every industry. Everyone, from automotive to aerospace, uses different types of 3D printing. NASA engineers even use such a device on the International Space Station to send tools and equipment to astronauts in orbit.

We already examined the example earlier where a group printed a rocket engine. It might not be long before we see entire spacecraft created by massive 3D printers, like those invented by Relativity Space. These enormous metal printers take up whole rooms and can create rocket components in a much shorter amount of time. They’re extrusion-style printers, but still an excellent example of what could be possible as additive manufacturing technology advances.

Powder bed fusion will likely become more popular and commonly utilized if researchers can improve the technology. Enhancements must include making prints faster and designing printers that use less energy than current models. If that happens soon, powder bed fusion may become a popular additive manufacturing option. If it doesn’t, it may be left behind in favor of other types of 3D printing.

Powder bed fusion and other forms of additive manufacturing are still in their technological infancy. However, they're quickly filling a niche in the manufacturing sector we didn't realize was empty until now. Currently, there are half a dozen different types of additive manufacturing methods, including powder bed fusion.

During the next five years, the technology of each of these methods will evolve and change. Those that can improve and become more efficient will likely become standard techniques, while those that don’t will fall by the wayside. It’s too early to tell which methods are going to survive and which will fail. As it stands now, though, powder bed fusion needs serious advancements before mainstream manufacturing will adopt it.