

## 3D Printing – the next industrial revolution

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Tells you what you need to know about this technology. It is enthusiastic, but not evangelical.

I bought this book because I had questions about what was possible with 3-D printing. This book gave a pretty good overview of what it can do, who the players are in the industry, and the prospect of future developments.

So these are the questions that I had:

What materials can it work with? The answer is that 3-D printing is most commonly done with plastics. The printhead melts plastic and applies it layer by layer to form a solid three-dimensional object. This is useful for forming models or creating die casts. One limitation of the process is that since each layer must be supported by the one underneath, a figure in which one part descends below everything else must be supported by props of one sort or another. You could build a cow from the legs up, but the udder would need a support. This doesn't seem like a tremendous shortcoming. Other limitations of plastic (melting temperature, hardness, and the fact that it is only a single material) are more significant.

What materials can be printed? For the time being, plastics are the most common. Ceramic and metal powders are also printed. They are suspended in a binder material which holds the work together as it is created. The end product is about 40% binder, 60% target material; brittle and infirm. Additional steps are used to remove the binder and infuse the product with metal (or whatever) to create a durable, solid product.

In some cases, plastics and metals can be applied in other than powdered form. They can both be melted. Certain liquid plastics can be "cured" optically, hardened by the application of light. One process has refined this to the level of individual photons; it can create incredibly detailed models. The limitations are again in the materials: they have plastic's inherent weaknesses, and they are expensive.

It appears to be difficult for the time being to mix multiple materials in the same 3-D printed object. This limitation is being overcome to some extent. Nonetheless, there was no indication that it was now possible, or would ever be possible, to print such complex devices as a motor with insulated electrical windings, or even a ball bearing. It seems that the tight tolerances, the need for lubricants or bushings and so on would make these things impossible to render with today's technology.

What is it used for today? Models, such as those to test the aerodynamic properties of race cars, prototypes so that people can look at what you propose in a design, casting masters for lost wax type for sand casting of metal parts, and direct manufacture of a few types of parts.

One of the problems with almost all 3-D printing is that it is slow. Just as an inkjet printer is slower than a LaserJet, the 3-D printing processes described here pretty much involved moving a single printhead

back and forth over an area. It has to traverse two dimensions at a time, and is stepped up through the third dimension layer after layer. The process is therefore quite time-consuming in all of the methods described.

There is one exception, which is to do laser type printing of different layers, and then use a physical glue to put them together. This is mentioned as sort of an afterthought; it is not really 3-D printing.

The idea of printing living tissue into three dimensions is also mentioned. How they do it is not. We know that skin grafts and some other tissues can be grown fairly effectively in laboratories and then applied pressure. Presumably, undifferentiated skin cells could be applied by some sort of a printing process. It seems unlikely that more complex organs could be grown. They did not discuss, and I cannot imagine how one would devise something as complex as a kidney using this process. The cells within such organs are differentiated, and at this point in time 3-D printing is not able to deal with so many different materials. Perhaps they could do it by using the same cellular material and trigger different gene expressions, making the RNA generate different types of cells. They are doing some fairly magical things in biotech, but this would seem to me to be on the outer fringes.

It is well-known that there are plans downloadable from the Internet for printing firearms using 3-D printing. It does not seem to me from reading this book that it would be possible to put together rifles with rifled barrels, the kind of thing that would yield an accurate and reliable weapon. One can conceive that you could create a chamber and a barrel capable of receiving a round of ammunition and firing it. But it seems unlikely that it would be nearly the quality of a machine manufactured rifle.

That is my take away from this whole thing. There are a lot of manufactured items in today's world, but relatively few of them are simple enough to be readily adapted to today's 3-D printing technology. It does not have the ability to deal with a large number of different materials, and does not have the ability to give those materials the physical properties that one needs for most manufactured items.

3-D will be useful for the things issues for now, models. It will be useful for producing one-off parts, such as a transmission gear for a 1941 Ford. If you can describe it in a computer what is supposed to look like, and it can be made out of solid steel, it would be something that would lead itself to 3-D printing. Producing the entire transmission would not seem to be possible, because it would not be able to produce the bearings/bushings and other such parts.

My take as a technology investor is a 3-D printing will continue to grow in applications. There will be some fairly substantial annual growth among the companies in the industry. However, it will never come to a sudden, revolutionary adaptation of 3-D printing, resulting in instant fortunes of the type made on such companies as Microsoft, Oracle, Cisco and Facebook. This is an industry for the long slog. It employs a lot of great people, and there is a lot of innovation, but no single innovation is likely to arrive that will have dramatic industrywide repercussions.

As far as home use goes, despite the author's enthusiasm, it is hard for this reviewer to envision a compelling reason to own one of these. I compare it to the color printer. I didn't get a color printer until they were cheap enough that it was a choice of why not. This is unlike the laser printer. I and many others ditched our dot matrix printers for lasers the moment we could, in the 1980s. It filled a major preexisting need, and HP made a fortune. I don't see that here.