

## 5. Rapid Manufacturing

*What RP will be when it grows up...*

### **Introduction**

#### **Definition**

Rapid manufacturing (RM) is the use of additive fabrication technology to directly produce useable products or parts. As is the case with rapid prototyping, the field is also known by several other names such as additive manufacturing, direct fabrication and direct digital manufacturing. It may also be referred to by the names of one or more of the several technologies utilized; a number which is continuously growing. See the Appendix for a complete discussion of terminology.

RM is one of the three major blossoming outgrowths of rapid prototyping. The others are three-dimensional printing - a lower-cost flavor of RP, and rapid tooling - actually a special case of rapid manufacturing. Today the distinctions among the trunk and branches of the RP tree are not very clear. Moreover, these differences can be expected to continue to blur as the technologies mature and applications, specifications and capabilities of the branches increasingly overlap.

#### **Present Status**

What we see today is only a pale outline of the future. A few RP systems specifically aimed at rapid manufacturing applications are just beginning to appear commercially. RM is not yet being practiced at present, at least publicly, in any large way. However, many experiments that adapt existing RP systems to specific RM applications are quietly underway in corporate, government and university laboratories. As technology, materials and other barriers are overcome, additive fabrication will find its way into the mainstream across a broad spectrum of applications. RM will be the branch of the technology that has the most direct impact on people's lives.

Some observers have likened it to a second industrial revolution. That may be going a little too far, but it's a good long-term bet that nearly all facets of life will be impacted in some way by RM - and many in ways which may not be apparent at present.

#### **Advantages and Disadvantages**

The fundamental advantages and disadvantages of rapid prototyping carry over to rapid manufacturing. The benefits of RM must be balanced against its substantial limitations today. Unless there is an overwhelming need for a specific advantage that RM provides, the balance most frequently favors a conventional approach. However, as technical problems on many fronts are solved, the balance can be expected to tip in favor of RM with greater frequency.

The driving force to solve these problems comes from the early adopters whose present applications already possess an overwhelming balance in favor of additive fabrication. These individuals and companies are providing the foundation upon which further improvements will be based.

**Geometric freedom.**

Essentially all additive fabrication technologies provide the ability to fabricate with unbounded geometric freedom. It's their most important advantage over subtractive methods and main reason to exist. Geometric freedom comes with several limitations using today's technology, however. The speed of fabrication compared to standard manufacturing methods is much slower. By some estimates, existing mass production methods are 10 to 1,000 times faster [1]. The finishes and accuracy are also not on a par with conventional technology. Secondary operations are also required, such as support removal and hand-finishing. In a production situation, where multiple parts are fabricated, secondary operations can add up and become time-consuming. There are also part size limitations at present which are more restrictive than those of standard methods.

**Materials.**

Additive fabrication offers the potential to use multiple materials as well as to control the local geometric meso- and micro-structure of a part. This means that the functionality of a part can be optimized in ways that are impossible with previously existing manufacturing methods. Materials can be selected for their mechanical, thermal, optical or other properties, and then can be physically deposited in a manner that optimizes or changes those properties beyond the capability of the intrinsic material itself.

On the other hand, the reality today is that the key word here is "potential." It will be a long time before the choice of materials available to rapid manufacturing is even remotely comparable to those available to standard manufacturing technologies. There are just a few dozen RP/RM materials commercially available today, spread out over all classes of materials such as plastics, metals and ceramics. In contrast, plastic selection databases exist that list a mind-boggling 40,000+ active grades of plastic alone [2]. In addition, recycling complex materials may be difficult or impossible.

**Elimination of tooling.**

CAD directly drives all additive fabrication processes, making it theoretically possible to avoid the use of tooling altogether. In practice, it may often still not be possible to do that because of process and materials limitations of one kind or another, but complementary rapid tooling technology might offer a beneficial compromise. When feasible, however, the complete elimination of tooling results in enormous savings in time and money. It makes it possible to fabricate parts and products in small quantities, or using materials and design parameters that might not otherwise be conceivable.

**Lowered costs.**

The ability to fabricate products more economically arises from several links in the RM process chain: One of the largest savings, as mentioned, is doing away with the need for tooling. Additional savings arise from lowered or zero inventory requirements, and eventually can be expected to arise from the ability to fabricate complete operational assemblies. The latter further lowers inventory costs and also does away with assembly labor. Of course, the economic potential described here requires substantial technological development to fully realize.

The establishment of distributed manufacturing is simplified once tooling and inventory requirements are done away with. Parts and products can be fabricated at the point of use and in the exact quantity required. For example, parts may be manufactured at the location of the final assembly line, or at a replacement part distribution site, or on a ship at sea or in outer space. It will only be necessary to inventory the requisite materials rather than many parts or sub-assemblies, or even the final product itself.

**The rest of the Chapter is Omitted  
in this brief sample.**