Rapid Manufacturing Today

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With the TCT Conference on Rapid Manufacturing about to take place in September and the 1st International Conference on Rapid Manufacturing having just taken place at Loughborough University, TCT takes a timely look at the current status of Rapid Manufacturing in industry.

To this end TCT magazine has invited members of its Editorial Advisory Board together with members of the TCT 2006 Steering Committee to respond to some pertinent questions on this issue and many of the responses have helped to shape this article. Some of the more probing responses are quoted in full.

The article itself aims to give the reader some insight into how the emergence of Rapid Manufacturing is taking shape and how it can and will affect global manufacturing communities in the coming years.

Terminology and Definition

Today the debate on Rapid Manufacturing continues to gather pace. People are talking about it — whether it be excitedly about the benefits it can bring to the manufacturing companies with the foresight to adopt it now, more reservedly about the current limitations of the technologies available or just at a basic level about what it means and whether or not a realistic definition is even in place yet for manufacturing industries in general to understand the implications.

It is probably prudent to start here, at this basic level. The most recent (and global) debate has been taking place on the rapid prototyping mailing list (RP-ML) [1] when the topic stream "Am I Dreaming?" from Marshall Burns, Ennex Corporation, which centred around the question: 'Does this mean the digital fabrication industry is finally out growing the constraining RP moniker?' prompted responses from many, with varying views on the definition of Rapid Manufacturing and indeed what to call it. The question was in response to an original email circulation from Terry Wohlers, Wohlers Associates, stating "The market for additive fabrication (also known as rapid prototyping) grew 14.6% to an estimated $808.5 million in 2005, up from $705.2 million in 2004." The activity on the RP-ML was as frenetic as any seen on this list in recent years — some extremely positive in a bid to move the industry forward and others much more reserved, even negative. The overwhelming notion that one could take from this activity though was that people had opinions and actually took the time to air them in an open and global forum.

Most people within the Rapid Manufacturing industry itself have accepted the strict definition as the way to go. The following comprehensive definition from Neil Hopkinson at Loughborough University, which is widely recognised as the leading academic institution for research into Rapid Manufacturing technologies and their applications, is echoed by the leading industry consultants in this area:

***Rapid Manufacturing**: "The use of a CAD-based automated additive manufacturing process to construct parts that are used directly as finished products or components."*

However, if you talk to manufacturing people on the ground that are up to speed on the technologies and processes available, the perceptions of RM are generally not so rigid.

The argument in favour of defining Rapid Manufacturing precisely is clearly to help promote what is still an emerging technology and make it easily and instantly recognisable to the masses, some of whom have so far ignored, overlooked or just never heard of Rapid Prototyping let alone Rapid Manufacturing.

And herein lies the next problem — what to call it?

The requirement for universally recognised terminology is one that will aid the initial transition period as the technologies find their place in industry. However, the current confusion that exists needs to be addressed to aid this transition and the ambiguities that prevail need clarification and consensus before this can happen.

The following is a comprehensive list of the many generic terms that are circulated and used by industry in this respect:

- Rapid Manufacturing (RM)
- Additive Fabrication
- Freeform Fabrication (FF)
- Additive Manufacturing
- Direct Manufacturing
- e-Manufacturing™
- Freeform Manufacturing (FFM)
- Digital Manufacturing
- Digital Fabrication
- Fabbers.

For clarity, there needs to be a distinction between the processes/technologies and the applications of the technology. Terry Wohlers is leading this quest and his qualification of this is simple when scrutinised:

"Additive Fabrication serves well as an umbrella term for the additive layer technologies (SLA, SLS, FDM, SLM, PolyJet, etc.), under which there are several applications of the technology. These applications can be grouped into three broad categories — design/concept modelling; fit/function prototyping; and Rapid Manufacturing."

It is perhaps understanding this point alone that is the key to universal recognition and acceptance.

However, it is likely that this particular debate will rumble on, despite the more sobering and probably realistic contribution to the RP-ML from Adrian Bowyer, a Senior Lecturer in the Department of Mechanical Engineering at the University of Bath.

"This recurrent debate, though mildly entertaining, is entirely pointless. It is predicted on the false assumption that a rather small group of people can decide what the word for something should be. As any philologist will tell you, that is simply not how language evolves. Sure, we can chuck terms into the mix, but what finally gets used will be decided by journalists, other writers and — when the technology becomes ubiquitous — the general public. And they will make that decision entirely on the basis of ease-of-pronunciation, brevity and euphony. Technical considerations will be completely irrelevant. If we do want to try to nudge this process of definition and labelling (and I can't quite see why we care), we should choose a single short word that is unused for anything else purely on the basis of its mellifluousness."

It is Real

The fact is that Rapid Manufacturing is here — however we choose to label it. Yes, it is still emerging, but there is strong evidence to suggest that many leading, global manufacturers and SMEs are already using additive fabrication techniques to manufacture the parts or components required for their specific applications. These companies are truly benefitting from the many rewards that come with the adoption of RM — improved time to market, eliminating tooling and its associated costs altogether, and the ability, in some cases, to manufacture products that just could not be made in any other way.

This last point is surely one of the most liberating characteristics of Rapid Manufacturing. The design freedom opportunities that rapid manufacturing affords — in terms of the ability to design without the constraints that are traditionally imposed on design engineers [2] — just cannot be ignored by any forward thinking, truly innovative manufacturing company.

The industries most often cited as the forerunners with RM technology are Aerospace, Medical and Formula 1 racing teams. The common factors for these industries that have prompted the use of RM, apart from the budgets that they have available, are the need for low quantities (sometimes as low as a single custom piece) of small, high value parts with complex geometry that is difficult to produce using conventional manufacturing methods.

In some cases, these companies are prepared to share the knowledge and demonstrate the benefits. The TCT Conference Programme on Rapid Manufacturing is testament to this fact, with companies such as Renault F1, Boeing Phantom Works, Rolls-Royce, Red Bull Racing, Sirona Dental Systems, Siemens Hearing Instruments, and many more willing to share and promote their experiences with RM [3].

In terms of overall awareness, it seems fair to say that manufacturing industry in general has not grasped the real potential that RM affords. According to Todd Grimm, T.A. Grimm Associates:

"I think the industry is doing itself a big disservice thinking like engineers and not manufacturing personnel. There are tremendous time and cost advantages that go well beyond the savings realised by eliminating tooling. Rapid manufacturing will impact nearly every discipline in a manufacturing environment, from production planning to inventory control, and each of these disciplines can realise big benefits, but, not enough people are talking about the issues and opportunities."

Technologies & Limitations

Given that the definition of Rapid Manufacturing is accepted as that stated above, then it follows that any of the rapid prototyping machines on the market today could potentially be used for RM. Unfortunately, this belies a problem area in terms of uptake of the technologies, because at present this is not the case — there are still significant variances between the different processes and also from vendor to vendor. In reality it is the sintering process that currently leads the way for Rapid Manufacturing applications, but stereolithography is chasing hard, specifically for medical and dental applications. The inkjet method of fabrication is also undergoing major research and development in this area.

The current limitations of the technologies themselves, however, are the major factor as to why Rapid Manufacturing is not being adopted by more companies. There appears to be a general consensus on the primary technological limitations, namely the properties of the materials available, the limited choice of materials and their prohibitive price. These issues are being addressed continually and the release of new and improved materials is advancing at a quicker rate than ever before. Other technological limitations include accuracy, surface finish, repeatability and part size.

Furthermore, aside from technology issues there are those who will attempt to categorise the equipment as either RP or RM, but according to Jeremy Pullin, Rapid Prototype Manager at Renishaw plc:

"It is both — and what's more it can perform both roles at the same time — so why not use it in this way? Does it really matter if the plant was purchased off the development budget or the manufacturing budget? Accountants may say yes but if engineers what to maximise the return on their investment then they should make the kit perform as many roles as it is suitable for."

In terms of innovation and driving the technology forward, it is the companies that are working with today's capabilities and pushing them to their very limits that are achieving the most remarkable results. Another way for manufacturers to approach Rapid Manufacturing is to take on board the opinion of Richard Bibb, PDR:

"While I do not believe that manufacturers, in general, are up to speed with the opportunities that RM offers; I do think that the manufacturers themselves should be much more involved in driving the technology to give them what they need rather than sit back and wait for the developments to come to them."

The Future

Looking ahead, the future for Rapid Manufacturing appears to be bright. The potential that these technologies offer to manufacturing industry should not be underestimated and the vast majority of new applications that will be achieved with Rapid Manufacturing have not even been conceived yet.

There is a vision of the future whereby the equivalent of today's 3D printers will be in place in people's homes, next to a PC. For new consumer purchases, the design data will be downloaded from the internet, with any personal modifications, and the product manufactured in-situ. The aim truly being 'mass individualisation.'

Of course the implications of this are huge and wide ranging, the more significant of these being the fundamental attitude shift from "mass production" to a more sophisticated approach that balances desirability, performance, costs and production volume; reduced environmental impact of transporting goods vast distances; and the ability of domestic organisations to compete on a level playing field with foreign companies.

This is not just 'Pie in the Sky'. This vision has been conceived based on the huge developments that are taking place within the field of nanotechnology. This area is probably the key to unlocking the real potential of RM. Below are details of just some of the research that is taking place in this field.

• Nanorex (http://www.nanorex.com) and the Foresight Institute (http://www.foresight.org/) have established a challenge grant to fund the production of a new computer-generated animated short film called "Productive Nanosystems: from Molecules to Superproducts." This was a collaborative project of animator and engineer, John Burch (http://www.lizardfire.com/), and pioneer nanotechnologist, Dr. K. Eric Drexler (http://www.e-drexler.com/). The film depicts an animated view of a nanofactory and demonstrates key steps in a process that converts simple molecules into a billion-CPU laptop computer.

• Read the article by Chris Phoenix from 'The Center for Responsible Nanotechnology: "Beyond RP/RM — Molecular Manufacturing" in issue 14.4 of The TCT Magazine. For further information the organisation's web site is http://crnano.org/index.html.

• Chris Harris, a Senior Partner at Future First Consulting and a speaker at tct 2006, will also cover this issue in his presentation at the conference.

While it is both exciting and prudent to explore these possibilities for the future, in the medium term, Neil Hopkinson's view of the future is probably the best thought with which to conclude this article:

"Within ten years RM technologies will be just another tool in the box for manufacturing enterprises. RM will take some market share from CNC machining and from moulding technologies and it will enable many products to hit the market where the financial and physical constraints of machining and moulding currently prevent ideas from becoming reality."

References

1. The Rapid Prototyping Electronic Mailing List (RP-ML): http://rapid.lpt.fi/rp-ml/
2. R. Hague et al, Design for Rapid Manufacture, http://www.lboro.ac.pt.fi/rp-ml/uk/departments/mm/research/rapidmanufacturing/projects/design_for_rapid_manufacture.html
3. TCT Conference Programme: www.time-compression.com/x/conferenceprogramme.html

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