The State of Additive Manufacturing: Opportunities and Challenges

A Mufson Howe Hunter Interview with Dennis Thompson, Equus Partners LLC[1,2]

Opening Comments

In some respects, today's state of additive manufacturing (AM), also known as 3D printing, is similar to the old Wild West. That's because the actual rules of engagement have not been defined, and it's difficult to assess what players will be permanent providers and which are transient.

Here's what we do know: AM holds the potential to transform many aspects of manufacturing and its supply chain. Furthermore, AM could also help stem the outflow of US manufacturing to offshore locations and present an opportunity for the US to re-establish its preeminence in manufacturing.

Newcomers to AM may ask "what is the roadmap to a given AM application?" Perhaps the best way to answer the question is highlighting the tried-and-true process steps, or building blocks, which have been adopted for implementation of other innovative manufacturing initiatives. These steps are:

- Education
- Relevant benchmarking
- Business case assessment and justification
- Prototyping, and
- Design for manufacturing processes, such as optimizing the materials, equipment and process steps by which the product is made.

Today, AM encompasses eight 3D printing machine technologies and seven classes of printing materials. As of early 2019, there were nearly 1,000 US AM players, including equipment vendors, service bureaus and material suppliers. While the field of participants is growing rapidly, many entrants are novices in the manufacturing sector and relatively few are established hardware players such as HP and GE Additive, or Autodesk in software. Eventually, it's possible that one or two handfuls of big equipment players, alongside several material suppliers, will dominate the market.

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[1] *This interview is an edited version of a series of conversations between Mr. Thompson and MHH in March, April and May of this year.*

[2] *Mr. Thompson is President & Managing Partner of Equus Partners LLC; please see the last page of this Interview for Mr. Thompson's Biography*

In the meantime, leading pure-play AM companies will react to evolving user and application needs, adapt their product offerings and gain greater market share as less-agile competitors either disappear or are swallowed by consolidation. It's also likely that AM will be embraced by many of the big machine tool players as they strive to maintain their strong competitive position on manufacturing shop floors.

Assessing AM providers

Understanding the technical and economic viability of AM companies can be difficult in this early stage. To help overcome this challenge, SME launched iRAMP[3], or **I**nteractive **R**apid **A**dditive **M**anufacturing **P**ortal, in May at its RAPID AM event. The first iteration of iRAMP includes a searchable database of AM resources and approaches for potential adopters. The tool can help identify the relevant types of AM machines and the specific manufacturers that meet the specifications for a given part.

The second phase of iRAMP will focus on cataloging AM service bureaus and their capabilities, while the third phase will emphasize the technical evaluation of parts and products produced using AM. In addition, an assessment tool called SAM-CT (short for **s**ize, **a**ccuracy, **m**aterial-**c**ost, **t**hroughput) will help manufacturing engineers evaluate current and newly designed manufactured parts to address real-world challenges, and help determine if an existing part can—and should—be made using AM. SAM-CT can also help engineers justify the business case for producing the part with AM.

To take advantage of the full capabilities of additive, existing CAD and other technical platforms will need to be adapted for AM. What's more, it will be necessary for AM manufacturers to educate potential customers about what the AM process can do and how it can be used.

Challenges among suppliers and users of AM

AM suppliers will need to provide prospective adopters with informed, reliable and unbiased help to transition from subtractive manufacturing to AM. To that end, Sandia National Labs (in conjunction with the work at Oak Ridge National Laboratory's Manufacturing Demonstration Facility) is developing "Born Qualified[4]", a formal base-lining process designed to help ease the transition of fabrication from subtractive to additive manufacturing. The initiative aims to ensure that the move to AM fabrication follows a disciplined, monitored, uniform and documented methodology.

Born Qualified should help convince regulators like the Federal Aviation Administration that a part has been fabricated according to strict, validated guidelines. It's encouraging that big

[3] https://www.sme.org/technologies/iramp/
[4] https://www.osti.gov/servlets/purl/1368510

players like Siemens and Dassault are supporters of Born Qualified and similar design-for-manufacturing (DFM) processes for AM.

Users of AM technology face their own set of challenges. These include a lack of industry standards, the absence of authoritative resources and uncertainty about whether current vendors will be around to support their offerings over the next five to ten years. Furthermore, prospective AM users should carefully consider the difference between what's technically feasible and what's economically viable.

AM is very likely here to stay and holds the potential to be a game-changer for much of manufacturing. However, companies should approach AM adoption cautiously to avoid getting caught up in the hype.

Perhaps the greatest potential downside to AM is the risk of cyberattack. The reliance on IT-based tools and data, both of which can be hacked, makes cybersecurity a major concern. It's also a challenge that requires a significant amount of expertise and constant attention. In addition, businesses that adopt AM will need to protect their IP and develop ways to validate part provenance.

Potential impacts on part production

To understand the likely impact of AM on traditional discrete part-production processes, it's helpful to look at two time horizons: the near term (e.g., over the next 24 months) and the longer term (e.g., beyond 24 months).

Companies that are intrigued by, but uncertain about, AM in the near term will likely conduct considerable research into the technology and what path to take. Those that decide to move ahead with AM, but lack technical expertise in the process, should consider identifying an AM supplier in their industry who is willing to engage in a symbiotic leader-close follower relationship. Thereafter, before making a full technical and financial commitment to implement additive, these close-followers should also work with a qualified AM service bureau to help reduce risks in their vetting process. These steps should help de-risk the transition for them.

To assure AM's long-term potential benefit, the early adopting companies should consider identifying low-hanging fruit ripe for AM adoption. Many AM practitioners are identifying quick wins such as AM fabrication of specialized pieces of production equipment that help hold, position, form, shape and/or otherwise facilitate the fabrication of disparate piece parts. Most contemporary manufacturing operations rely on these auxiliary tooling and fixturing pieces to produce piece-parts, components and finished goods. Manufacturing, as we know it today, cannot function without these auxiliary parts.

American companies had traditionally produced the vast majority of these auxiliary parts in the US. Over the last decade, however, it is estimated that 37% of this production has moved offshore. The complexity and relatively small lot sizes of auxiliary parts mean they are likely to be among the first pieces produced successfully via AM. In that regard, AM over the longer term could help reverse the "offshoring" trend, which would be a terrific strategic outcome for US manufacturing.

Another area for potential broad application of AM is the production of spare parts for maintenance, repair and overhaul activities for a variety of equipment producers, including those in the transportation, industrial, medical and technology sectors.

Impact of AM on supply chains and industry sectors

The supply chain in many sectors—including commercial and military aviation as well as specialized industrial and transportation equipment—could perhaps be more impacted by the adoption of AM than traditional manufacturing fabrication and production. One possible outcome of such adoption is a reduction in both the number of layers and the complexity of supply chains. The opportunity for lower costs and faster delivery times is significant.

What about AM's impact by industry sector? It seems likely that sectors which deploy expensive, complex assets across broad geographic locations, such as the military and defense sector, will be among the earliest adopters. As noted earlier, spare and replacement parts are two areas in which AM can have an immediate positive impact. Consider that the US Army is already using AM fabrication for new parts in the field. In fact, soldiers have produced and installed additive parts when OEM components have failed and supply chain spares were unavailable.

High value/lower volume vs. medium value/high volume…… or both?

At this early stage, many businesses are trying to determine whether AM will be used primarily for high-value, low-volume parts in sectors like aerospace and defense (A&D), or if it will become cost-effective for medium-value, high-volume parts in industries such as automotive.

Clearly, significant potential exists for adoption of AM in aerospace and defense due to the higher-value, lower-volume characteristics of OEM parts as well as parts fabricated in, and for, the extensive A&D supply chain. Furthermore, it seems likely that AM will also be broadly adopted in the automotive and transportation sectors for fabrication of spare parts as well as for the potential "mass customization" of vehicles. Consider, for example, this scenario: Prior to vehicle delivery of the basic vehicle, 3D printers installed at the dealer could fabricate body trim and other custom parts to tailor the basic vehicle to specific consumer preferences. In addition to better meet evolving consumer needs, this approach also has the potential to reduce the order-to-delivery timeline significantly.

Some parting thoughts

Conceptually, AM is a new way to think about manufacturing, and its impact could be similar to that of "just-in-time" manufacturing introduced by Japanese automakers in the 1960s and 1970s. In those early years, few US manufacturers understood the just-in-time methodology, and even fewer grasped its full impact. Nonetheless, many of the larger OEMs were concerned about the consequences of getting left behind and, therefore, embraced this "demand-pull" concept of production which eventually transformed material logistics and production flow while improving overall operational efficiency. I believe we could see a similar dynamic with AM, which is quickly gaining momentum and could be even more transformative.

Machine tool companies, in particular, are well positioned to capture the hearts and minds of manufacturing engineering and production resources across industries. Companies like DMG Mori and Mazak are already considering adoption of AM as part of their machine tool systems. Furthermore, a few machine tool companies have already demonstrated hybrid systems that fuse subtractive and AM capabilities. The adoption of AM by these classic subtractive manufacturing equipment suppliers could eventually swallow up and/or eliminate some of the smaller pure-play AM companies.

Adoption of AM by significant OEMs will be critical to AM's acceptance and growth. Consider Caterpillar, which appears to be emerging as an early adopter. This construction equipment manufacturer is using AM to design and build a part for one of its backhoes. But rather than producing parts in house, Caterpillar is procuring the part from a former CAT engineer who has started an AM company to supply certain parts to CAT (and presumably to other customers as well).

About Dennis Thompson:

Dennis is the President and Managing Partner of Equus Partners, a manufacturing consultancy specializing in digital manufacturing, next generation supply chain risk analysis, mitigation and management with a focus on Model Based Enterprise (MBE), Advanced Manufacturing Enterprise (AME), Network Centric Manufacturing (NCM) and Additive Manufacturing (AM). The list of Dennis' past and present clients includes; the White House, the Ohio Supercomputer Center, UI-Lab/DMDII, Prime Supplier, NOBLE Capital, FUMEC, SME, the Office of the Secretary of Defenses (OSD), the Air Force Research Lab (AFRL), and NASA.

Two of Dennis' present clients are pushing the envelope to facilitate the adoption of AM. He is acting as Program Manager for an innovative program being developed by SME called ITEAM (Independent Technical Evaluation of Additive Manufacturing). SME is creating ITEAM to help the manufacturers that are looking into using AM by answering the two basic questions about AM: "Can I make my product using AM?" and "Should I make it using AM?" Dennis is also working with FUMEC and the Mexican government to help them create a Bi-National AM Center of Excellence to produce molds and dies.

Dennis has also worked with other programs focused on creating and deploying disruptive technologies, having served as the Program Manager of a White House initiative, the National Digital Engineering and Manufacturing Consortium (NDEMC) which created a program to bring Modeling & Simulation and High-Performance Computing (M&S/HPC) to small and mid-sized manufacturers. He also was the acting Director of Technology Transition and Workforce Development (WFD) for the Digital Manufacturing and Design Innovation Institute (DMDII). Additionally, Dennis is serving as Chief Operating Officer for Prime Supplier and the Chief Technology Officer for NOBLE Capital, two new startup technology companies.

Dennis has 40+ years of manufacturing expertise having held various senior level positions including: Engineering Manager, Plant Manager, and Vice President of Operations as well as President and CEO.

Dennis and Equus Partners have been able to fill a unique and critical role for clients by being the manufacturing subject matter expert and/or program manager to interface/liaison between manufacturing client and engineering service providers in developing project definition, the scope of work and leading programs.

About Mufson Howe Hunter & Company LLC:

Mufson Howe Hunter & Company LLC is an investment bank specializing in mergers & acquisitions, recapitalizations and private placements of debt and equity for middle market companies. Our senior professionals are seasoned investment bankers with over 20 years of experience each and have completed more than 500 transactions for clients. We have completed transactions in many industries, but are particularly strong in business services, consumer products and services, technology services, retail, life sciences, manufacturing and wholesale/distribution. Through our affiliate, Mufson Howe Hunter & Partners LLC, we are a registered broker/dealer with FINRA and a member of the SIPC. Learn more about us at www.mhhco.com.