AGMA 3D Printing and New Materials Committees

Summary of Activity - 2019

3D Printing Committee Chairman
Justin Michaud, President
REM Surface Engineering

New Materials Committee Chairman
Bill Bennett, Metallurgist
Ellwood National Forge

The AGMA 3D Printing and New Materials Committees teamed up for 2019. The main goal was to answer the most obvious question: *Are people commercially making metal gears using 3D printing or additive manufacturing?* The committees were fortunate to have an expert volunteer assist us for the year, Kirk Rogers, PhD, Senior ADDvisorSM of The Barnes Group Advisors. The committee also engaged individuals from within AGMA member companies with specific backgrounds in powder metal, metallurgy, and related backgrounds that would be able to provide the needed expertise – specific to gears - in these discussions. Together these individuals helped author the AGMA Emerging Technology first white paper, which was released in April, followed immediately by a Q&A webinar with authors. This paper outlines the current state of gears in additive manufacturing.

In May, the Committees sponsored an expert-led tour on the floor of RAPID-TCT+ where more than 30 AGMA member executives were introduced to 13 metal additive manufacturing companies, met with their leaders and were able to ask their individual questions about the technologies. Throughout the year, committee members were afforded many discussions with experts from within the field (*list of companies at the end of this document*) and brought additive manufacturing guest speakers to AGMA events.

The committees were able to provide robust information to AGMA members throughout the year. If you missed some of this, here are some of the highlights of the information that was discovered:

- This is an emerging field with new companies coming into the scene in rapid succession.
- The field brought new techniques and improvements to current techniques in additive manufacturing in 2019.
• Work needs to be done in molecular structure and surface finish before this technology can be used to produce gears widely on a commercial basis.
• Aerospace and specialized fields in medicine saw a lot of growth in the area of new materials development for additive manufacturing.
• Manufacturers can find immediate benefits of utilizing 3D printing for fixtures, work holdings and some tooling.

WHITE PAPER

In April, 2019 AGMA 3D Printing and New Materials committees released *Additive Manufacturing Technologies for Gears*. The paper was part of the AGMA Emerging Technology Committee’s commitment to bring information on disruptive technologies to AGMA members. The paper’s main theme was that gears are being made using additive technology methods. Kirk Rogers, PhD, Senior ADDvisorSM of The Barnes Group Advisors was brought on to author the paper with significant input from members of both committees. The transition of the 3D printing technologies from legacy uses in rapid prototyping to true manufacturing is already taking place in the aerospace, defense and medical implant industries. The AGMA Emerging Technology Committee worked to provide a look at this technology with focus directly placed on gears. This paper discusses the seven different additive manufacturing technologies in metal printing, as defined by ASTM Committee F42, that are well-known for the ability to reduce the price of complex components, reduce the number of assembly parts in high-level assemblies, and to provide next generation performance by enabling complex designs.

The paper discusses opportunities for the power transmission industry in additive manufacturing (AM):

• Manufacture complex geometries such as internal cooling or lubrication channels
• Reduce gear system inertia using advanced designs that are difficult to manufacture conventionally
• Improve durability using multiple optimized materials in a single part
• Change the cost of manufacturing by only placing material where it is needed
• Reduce product development time and time to market; and
• Improve safety, repeatability and assist humans with aids and tools.

The paper also discusses disruptive AM technologies that may impact power transmission. It highlights specifically, gear materials and additive manufacturing.

It is currently available in the store on the AGMA website at [www.agma.org](http://www.agma.org). It is free for members and is available to non-members for $99.
RAPID-TCT+ Tour

Executives from AGMA member companies were able to meet with and see technology from the following companies:

- 3DEO
- EOS North America
- GEFERTEC GmbH
- HP
- Mitsubishi Heavy Industries
- REM Surface Engineering
- Xact Metal
- Desktop Metal
- GE Additive
- GKN Powder Metallurgy
- Markforged
- QuesTek
- Velo3D

MPT Conference – 3D Printing guest speakers

In October, committee brought two experts to speak at the inaugural MPT Conference. Kirk Rogers, PhD, provided an in-depth look at the development of technology in this sector. Jeff Grabowski discussed specific advances in materials development and in how some companies are designing their own materials for specific projects.

ADDITIVE MANUFACTURING – Machines and techniques

We have spoken with a wide variety of individuals from Jonah Myerberg, Co-Founder and Chief Technology Officer at Desktop Metal to a metal technology researcher in Brazil who is working with WAAM technology (Wire and Arc Additive Manufacturing). Most 3D printing machines fall into one of four types: Binder jetting, powder bed fusion, direct energy deposition, and materials extrusion. But within each of these are many vendors who have product lines that utilize these technologies in slightly different ways.

At the bottom of this document is a list of the companies that interacted with the AGMA 3D Printing Committee in 2019.

ADDITIVE MANUFACTURING – New material development

AM is popular because of its ability to push limits outside conventional manufacturing to produce unique shapes that are difficult or impossible with traditional tooling. Metals that are well suited for welding and casting are ideal for 3D printing. Additionally, metals and alloys that are difficult to cut are well suited for this process.

We have seen in 2019 a surge for aerospace, some automotive, and medical sectors adopting 3D printing.
Popular metals used in 3D printing include aluminum, copper, Inconel, stainless and tool steels, titanium, and tungsten.

**COMMITTEE GOALS FOR 2020**

The 3D Printing Committee will merge with the New Materials Committee making just one committee that is looking into this area. The goals for 2020 are to do a deeper dive into binder jet for small MIM-type gears, L-PBF for high end applications and DED for large gear repair.

The committee will have a minimum of 4 meetings in 2020:

- Friday April 3rd 2 PM CST – this will be one week after AMUG
- Friday May 1st 2 PM CST – this will be one week after Rapid
- Friday September 25th 2 PM CST – this will be one week after IMTS
- Friday December 4th 2 PM CST – this will be after Formnext

**HOW CAN YOU PARTICIPATE?** Join a committee – Emerging Technology Committee participation is open to all employees of member companies. You do not have to be an expert in the technology – you just must have a desire to learn more and engage with experts. We also encourage experts in the field to meet with us. Contact Mary Ellen Doran, Director – Emerging Technology at doran@agma.org for complete information.

**COMPANIES**

**3DEO**

3DEO’s Intelligent Layering® metal 3D printing technology unlocks the potential of high-volume additive manufacturing by dramatically reducing final part cost. Despite the low cost, our high-quality parts meet widely accepted MIM quality benchmark MPIF Standard 35 while still achieving tight tolerances and the best surface finish in metal 3D printing. 3DEO is a high-volume service bureau and will open additive manufacturing to most industries that can’t afford it today.

**Cincinnati**

Cincinnati was founded in the late 1890’s as The Cincinnati Shaper Company. They have become a leader in the manufacture of metal fabrication equipment. In addition to conventional machines they currently make a variety of 3D printing machines that have become well known in that industry.

**Desktop Metal**

Desktop Metal is accelerating the transformation of manufacturing with end-to-end metal 3D printing solutions. Founded in 2015 by leaders in advanced manufacturing, metallurgy, and robotics, the company is addressing the unmet challenges of speed, cost and quality to make metal 3D printing an essential tool for global engineers and manufacturers. The company offers two systems that cover the full product lifecycle, from prototyping to mass production. The Studio System is the first office-friendly metal 3D printing system. Its three-part solution automates metal 3D printing and enables rapid prototyping right in an engineer’s office or on the shop floor. The Production System, created by the inventors of binder jetting and single-pass inkjet technologies, is the world’s fastest metal printer, delivering the lowest cost per part needed to compete with traditional manufacturing with the highest capacity of any metal 3D printing system available.

**EOS North America**
EOS is the world’s leading technology supplier in the field of industrial 3D printing of metals and polymers. Formed in 1989, the independent company is a pioneer and innovator for comprehensive solutions in additive manufacturing. Its product portfolio of EOS systems, materials, and process parameters gives customers crucial competitive advantages in terms of product quality and the long-term economic sustainability of their manufacturing processes. Furthermore, customers benefit from deep technical expertise in global service, applications engineering and consultancy.

**Fortify**

**GE Additive**

GE has been a leading user of additive manufacturing, producing parts across multiple businesses. In 2016 the company announced the launch of GE Additive, a new business that leverages GE’s experience and expertise in additive technologies. GE Additive offers additive metal machines (both laser- and EBM-based), materials, and engineering consulting services.

Recognizing the vast potential of additive, GE Additive is committed to the advancement of the industry through innovative product offerings.

**GEFERTEC GmbH**

**GKN Powder Metallurgy**

GKN Additive is a digital manufacturer of metal AM parts and materials for prototypes, medium series and the aftermarket. Our AM production plants are embedded in Industry 4.0, backed by an intelligent global print network for maximum efficiency and prompt delivery to our customers. What sets us apart is our history.

GKN Additive builds on GKN Powder Metallurgy’s dual expertise in powder production and metal processing to drive industrialization across the whole Additive Manufacturing value chain. From advanced metal powders to design and manufacturing services, we drive new technologies to the limit to make technology simpler, faster and more accessible.

We are accelerating the future to make it a reality. Additive Manufacturing has the potential to transform future product thinking and traditional manufacturing. It allows new shapes of rapid prototyping and rapid manufacturing, as well as customized shapes of complex metal building components. We adopt our operational and digital capabilities to AM to create a new level of speed and productivity and enable customers to rethink existing ways of developing products.

**HP**

**Markforged**

As one of the most well respected and innovative 3D printing companies in the market today, Markforged’s mission is to bring high strength 3D printing to every production shop and desktop. Offering the world’s only 3D printing systems capable of automatically reinforcing engineering plastics to aluminum levels of performance and beyond, Markforged enables every business to easily manufacture parts with structural strength right on the desktop. Markforged Industrial Strength 3D Printers empower professional users to affordably create workhorse 3D parts that solve real problems, as well as realize reinforced structures never before possible. Markforged technologies are delivered with thoughtful, powerful software designed for collaboration, sharing, and scaling.

**MELD Manufacturing**

MELD is a revolutionary solid-state technology for additive manufacturing of metal and metal matrix composites. Aeroprobe offers full-scale MELD machines, contract manufacturing of components, and associated products and services.
MELD machines produce near-net shape components in a wide range of materials. One MELD machine allows manufacture of fully built parts, coating existing structures, performing repairs, and joining similar and dissimilar materials using a wide array of metals in solid or powder form. Materials used include unweldable metals.

MELD offers very high-quality depositions at 100% density with equiaxed grain structures, refined grain size, and excellent as-deposited properties. The residual stress formed in the deposited components is much less than stresses developed during casting or other processes that involve melting and solidification. MELD yields a metallurgical bond between the deposited material and substrate or previously deposited layers.

**Mitsubishi Heavy Industries**

Our company, Mitsubishi Heavy Industries Machine Tool Co., Ltd. (MAT), together with Mitsubishi Heavy Industries Ltd. (MHI), joined the Technology Research Association for Future Additive Manufacturing (TRAFAM) in 2014, which was established by the Ministry of Economy, Trade and Industry as a national project. Since then, the two companies have worked on the development of a metal-based additive manufacturing system with directed energy deposition technology. The system that MAT has developed is a hybrid system with an additive manufacturing function and a machining function, and it enables high-efficiency, high-precision additive manufacturing by applying the function of process monitoring during manufacturing and a powder feed nozzle with an increased shielding performance. At present, jointly with industrial users from various fields, we are promoting the development of an additive manufacturing method that can be put into practical use. Mitsubishi DED (Directed Energy Deposition) AM system will revolutionize the manufacturing scene with unprecedented

**QuesTek**

QuesTek is recognized as a global leader in materials science and engineering and focuses on having a metallurgical understating of materials processing and performance issues.

There are significant materials challenges in metallic Additive Manufacturing, and QuesTek has been at the forefront of research in modifying the alloy chemistry (to improve mechanical performance and ensure printability) and optimizing heat treatment processes of the major alloy systems including high strength steel, stainless steel, aluminum, nickel, titanium, copper and magnesium alloys.

In addition, QuesTek has designed, atomized, printed and measured properties on several new alloys that have performance improvements over current legacy alloys commonly used today in AM. These materials are available as powder and/or wire for AM trials and application:

- High strength, carburizable Ferrium C64 steel for gears, tools and dies
- Higher strength and ductility upgrade over Ti-6-4

Printable aluminum alloys with (i) high strength at room temperature (82 ksi YS and 8% el) and (ii) at high temperature (35 ksi YS at 250°C

**REM Surface Engineering**

REM Surface Engineering is a global provider of surface engineering solutions. REM’s Extreme ISF® Process, is a suite of subtractive, isotropic superfinishing processes tailored to the metal additive manufacturing industry. The technology can reduce the extreme surface roughness associated with metal additive manufacturing while removing or remediating surface and near surface defects such as voids and v-notch failure points and providing a mirror-like aesthetic appearance. Applicable alloys include Ti 6-4, Nickel-Based Superalloys, Stainless Steels, Maraging Steels, and Aluminum Alloys. REM offers the Extreme ISF Process as an outsourced solution or as a complete technology installation.

**Synergy Additive Manufacturing LLC (SAM)**

Synergy Additive Manufacturing LLC is a certified company specializing in high powder laser-based solutions for complex manufacturing challenges related to wear, corrosion and tool life. We provide laser systems and job shop services for laser heat treating, metal based additive manufacturing and laser welding.

**Velo3D**
VELO3D provides industry changing capabilities that enable broad adoption of 3D printing for manufacturing. The VELO3D metal additive solution is comprised of the Sapphire production system that works in concert with the Flow print preparation software. Leading manufacturers use VELO3D technology to produce applications previously considered impossible to manufacture. Learn how VELO3D can boost your product performance, radically speed up your development or significantly reduce your product cost.

Xact Metal

Don’t be held back by weak tech or traditionally expensive machines. At Xact Metal, we’re taking the essential specs that metal powder-bed fusing additive manufacturing systems require, combining them with breakthrough technology to save you money and establishing a new level of price and performance. We’re dedicated to supporting the next generation of innovative manufacturing solutions powered by metal 3D printing.