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Additive Manufacturing

face to face with Johannes Gartner

VP of Additive Manufacturing Austria

Additive Manufacturing (AM) and big industry: the state of play and a glimpse of the future

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Research[1] published last year by Statista predicts that 3D technology will be a highly disruptive force for global manufacturing, with the emphasis shifting from the production of prototypes to full-scale manufacturing of parts and accessories. Statista's research states that AM will enable finished products to be manufactured on a large scale by 2030. Given its growing importance, Futurities decided to dedicate its "Spotlight" to exploring the different facets of this production disruptor, beginning with this interview with Johannes Gartner, VP of Additive Manufacturing Austria.

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References

[1] www.statista.com/statistics/560323/worldwide-survey-3d-printing-top-technologies

Q. Can you give us an overview of the Additive Manufacturing approach at present?

A. Additive manufacturing (AM) is not one homogenous technology – it is a production paradigm, similar to subtractive manufacturing (that removes materials from a whole block to shape a certain structure or product by means of drilling, milling, or planing) or to forming manufacturing (that uses heat and/or pressure i.e. moulding, bending, and pressing to shape a structure).

The ISO and ASTM standards organizations currently define additive manufacturing simply as "a process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies".

There are currently at least seven basic processes defined by the ISO and ASTM to combine, melt, sinter, polymerize and bind materials. Beneath each of these processes are multiple companies offering different technological solutions which results in a wide variety of niche technologies all being gathered under the umbrella title of AM.

When the public thinks of additive manufacturing many have simple consumer devices (based on fused lamination) in mind and believe that it is quite a recent technology. However, the first AM technology, stereolithography, was already invented in the mid-80s by Chuck Hull from 3D Systems. He successfully combined technologies of the time – UV lasers, optics, and photopolymers – into a clever mechatronic system to create the first additive process. Many other techniques followed and were initially mainly used to produce prototypes for some industries like automotive but didn't attract much public attention.

The "niche" AM technology businesses with their high margins and patent protection created significant barriers to entry to the market for a long time, but that started changing when an open-source version of the expired fused deposition modelling (FDM) patent was published by the British engineer, Adrian Bowyer. The project, called RepRap, was welcomed by the maker community and led to the creation of many startups, attracting a lot of attention and resulting in some over-expectations. A kind of 3D printing hype peaked around 2013 as the market wasn't ready to support so many manufacturers. However, the interest and motivation around these technologies continued and has led to much riper technologies and many applications.

While the AM market, currently estimated at US$15.2 billion (Wohlers Report 2022), is still minor compared to traditional manufacturing, it has been growing in two-digit percentages year after year for the last 20 years. It therefore bears all the indicators of a very disruptive technology.

Q. What are some of the most interesting application areas at present?

A. There are applications for Additive Manufacturing at all levels of research, development and production across a variety of industries – from food and biomedicine, to dental, automotive and aerospace. The most exciting areas of development can currently be found in the industrial and medical industries and involve the use of a variety of materials – polymers, metals, ceramics and compounds. This opens up new opportunities for the traditional metal or polymer industries i.e. through the creation/addition of fibre-reinforced polymers or ceramic elements. As a result, we are now seeing an increased blurring of borders between traditional material silos.

Q. What are the most important advantages and benefits of AM?

A. Additive processes offer the ability to produce extraordinarily complex, intertwined, or inner structures that are impossible to mill or mould. In this space, AM is already being used, for instance, to create lightweight structures to achieve up to 60% less weight with greater durability (as an example of this, see GE Aviation using AM to produce lightweight parts for Boeing and Airbus). Even if the production cost might be a bit more expensive at first, the fuel savings or greater efficiency offset these costs.

Another huge advantage of AM, considered as a form of digital production, is its ability to produce individualized parts to achieve high customization. In a fully automated process based on digital 3D models it is irrelevant whether 100 identical parts or 100 distinct parts are produced.

Q. Can you give us some examples of how AM is disrupting various sectors?

A. There are some very disruptive AM business models in the industrial and medical sectors, and there are also many promising experimental and research applications. One area where we are seeing massive adoption of AM to generate complex and highly customized parts is in the medical sector – for instance in the dental implants, prosthetics, and prostheses industries.

Courtesy of Lithoz

One prominent example is Invisalign, a form of transparent braces for teeth. This fully customized product has some specific advantages for patients, while benefitting economically from a highly digitized production chain. Such digitally supported individualized medical treatment offer the potential to reduce prices for consumers and medical insurers/public health providers.

A comparable disruptive application in the medical sphere can be found in the area of hearing aids: by taking a 3D scan of the inner ear, a unique inner ear shell can be automatically generated and printed for a perfect fit.

So, wherever business models are able to combine automation and individualization an attractive business case can arise. In addition, it is expected that as the technology becomes more widespread, economies of scale will come into effect and machine and material costs will fall.

Q. What are some of the bottlenecks affecting the adoption of AM by industry?

A. One of the major bottlenecks around the adoption of AM, in my opinion, is that many engineers are currently still trained on traditional manufacturing technologies that have more limitations.

As AM offers more freedom of design, a kind of additive thinking approach is required to completely rethink products that have been optimized for other manufacturing principles. This requires a change in the education and training of engineers.

Q. What is the connection between simulation and AM?

A. Many think that simulation should be a competitor to AM, yet it isn't; it is facilitative and supportive. The need to create prototypes before the physical realization of new products is greater than ever. Prototypes are used even more than before because of more complex products, more product variations, shorter product life cycles, and the rule of ten: mistakes early in product development multiply the costs of stepping back in the process to correct them by a factor of ten. As a result, developers invest significant effort in planning before mass producing a part. Simulation software and additive manufacturing both play an important role here.

Courtesy of Lithoz

An example is the use of AM to generate inner layer temperature structures for injection moulds to perfectly control temperature for higher efficiency and better quality. With AM, the mould can simply be printed directly with perfectly organized inner layer temperature pipes but simulation software is required to first calculate the optimal temperatures to be maintained, and the consequent optimal structures and positions of these inner layer pipes. Combining simulation and AM therefore enhances the availability of this tool and can increases production speed. These benefits would not be possible without using this combination of simulation and AM.

Another prominent example of this winning combination is the ability to generate a product with a grid bone structure. Previously, it was laborious and manually intensive to translate a full block of metal into such a structure; today, the ideal or optimized structure can be calculated with simulation software and then printed directly using AM.

This brings us back to the issue of skills: there is a lack of expertise in the market regarding the use of simulation tools and AM, and the skills are highly sought after. Trained AM engineers are lacking, and the skills are diffusing too slowly within the education system because there is still too large a focus on traditional manufacturing techniques and not enough on AM techniques. This will change in time, but it is not changing far or fast enough yet.

Q. Are there any other challenges to be aware of?

A. Generally, in industry, trying to print a part that has been optimized for traditional manufacturing is the wrong approach. Instead, the parts need to be ideated from scratch, starting with the customer value in mind to enable additional customer value and, in the best case, to simultaneously reduce the production effort (i.e. by consolidating the production of the various parts).

We are dealing with a bias of expertise in the market: engineering experts who know too much about traditional techniques are often not able to see new opportunities. There is also a high learning curve involved: studying this new production paradigm requires time and some trial-and-error experience, but engineers in traditional manufacturing sectors often do not have enough time for this due to the demands of their workdays.

In the short-term, I think that companies should just get started to better understand the opportunities of AM. Rather than immediately investing in a costly additive manufacturing solution, they can start training their employees in additive thinking using a low-cost machine, and they can make greater use of specialized service providers. There is lots of knowledge stored in AM service providers that can be leveraged without a company needing to make a big investment immediately.

Comparable with cloud computing, there is an extensive network of AM service providers around the world where industrial grade machines can be accessed.

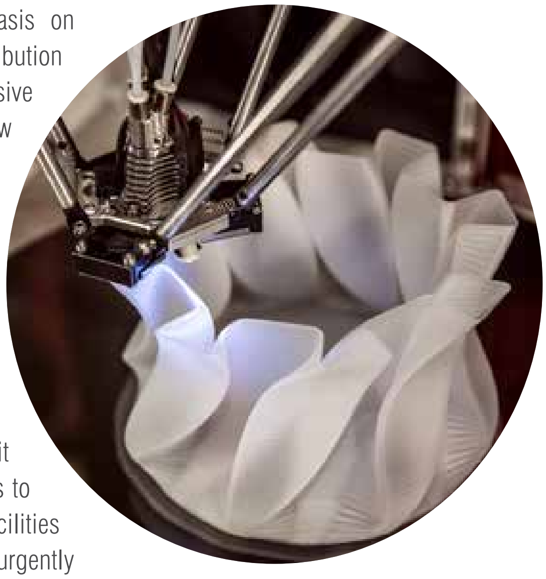
Q. Where is more investment needed?
A. This depends on the stakeholder perspective. There is already a very lively start-up scene and lots of research in the different areas of science.

In my opinion and as mentioned before, investment into training and education is one of the most critical areas. Furthermore, it is important to get policy makers to recognize the important of AM for a country's industry.

For instance, if we take Austria, a highly developed and industrialized market with many SME producers that are responsible for a majority of jobs, it is very important to them to master new production technologies to remain competitive internationally and to ensure that digital manufacturing and its added value does not migrate abroad, as was the case with the majority of the internet industry. This is especially important in the digital age where new technologies are already replacing many jobs.

Q. What do you see in the future?
A. Europe still has the opportunity to be a major player in the AM industry because many patents and developments are already happening in Europe. Unfortunately, the continent doesn't have the same venture funding systems as the USA, nor the public initiatives of China and the Middle East.

We are also seeing more emphasis on AM post-pandemic as global distribution chains are affected by successive crises. The AM product market grew even in 2020 and 2021 and has not been impacted like other industries. I believe that the reason for this can be found in its digital and local characteristics – it provides the ability to produce flexibly and independently on site.



This is one of its big benefits: it allows governments and businesses to have multifunctional production facilities onsite that can continue to produce urgently needed parts, i.e. to keep their critical infrastructure running. We are already seeing such applications in the military sector. Since in a war situation you cannot know what will break down, and the logistics chain is often extremely complicated or even at risk, the US military is equipping its aircraft carriers with AM machines to enable it to produce whatever replacement parts are necessary wherever the carriers are and in whatever circumstances.

Q. What about the issues of sustainability?
A. Onsite AM production also offers sustainability advantages. AM uses energy, of course, but a massive part of CO_2 emissions internationally comes from the global transport of semi-assembled parts.

Moving to onsite production requires less transportation and enables you to only produce what you need as you need it. However, AM is still currently quite centralized, so the full benefits of these savings on transportation are not yet being fully realized. But we are seeing some fast-moving consumer goods (FMCG) players who are starting to leverage some of these benefits, for instance when it comes to the availability of replacement parts after the end of life of products. If a company had to stock all these obsolete parts just in case, it would generate a lot of waste, not to mention the warehousing costs. Using AM, they can produce the specific replacement parts as necessary and thereby prolong the lifetime of their products.

Another aspect regarding the sustainability of AM is that its many processes only require the amount of material that goes into producing the product, unlike subtractive techniques that still generate a lot of waste. Then, as mentioned earlier, positive sustainability effects already arise from the applications themselves.

For example, the reduction of fuel/energy consumption through light-weight parts for aerospace or e-mobility applications. This has a positive effect for industry in terms of costs and also for the environment. So, used correctly, AM has major potential to be a green technology.

About Johannes Gartner

Dr. Johannes Gartner is Vice President of Additive Manufacturing Austria, co-founder of 3Druck.com, the leading German-language online magazine for additive manufacturing, and of 3Printr.com, and he is a technology management researcher with a doctorate from Johannes Kepler University in Austria.

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