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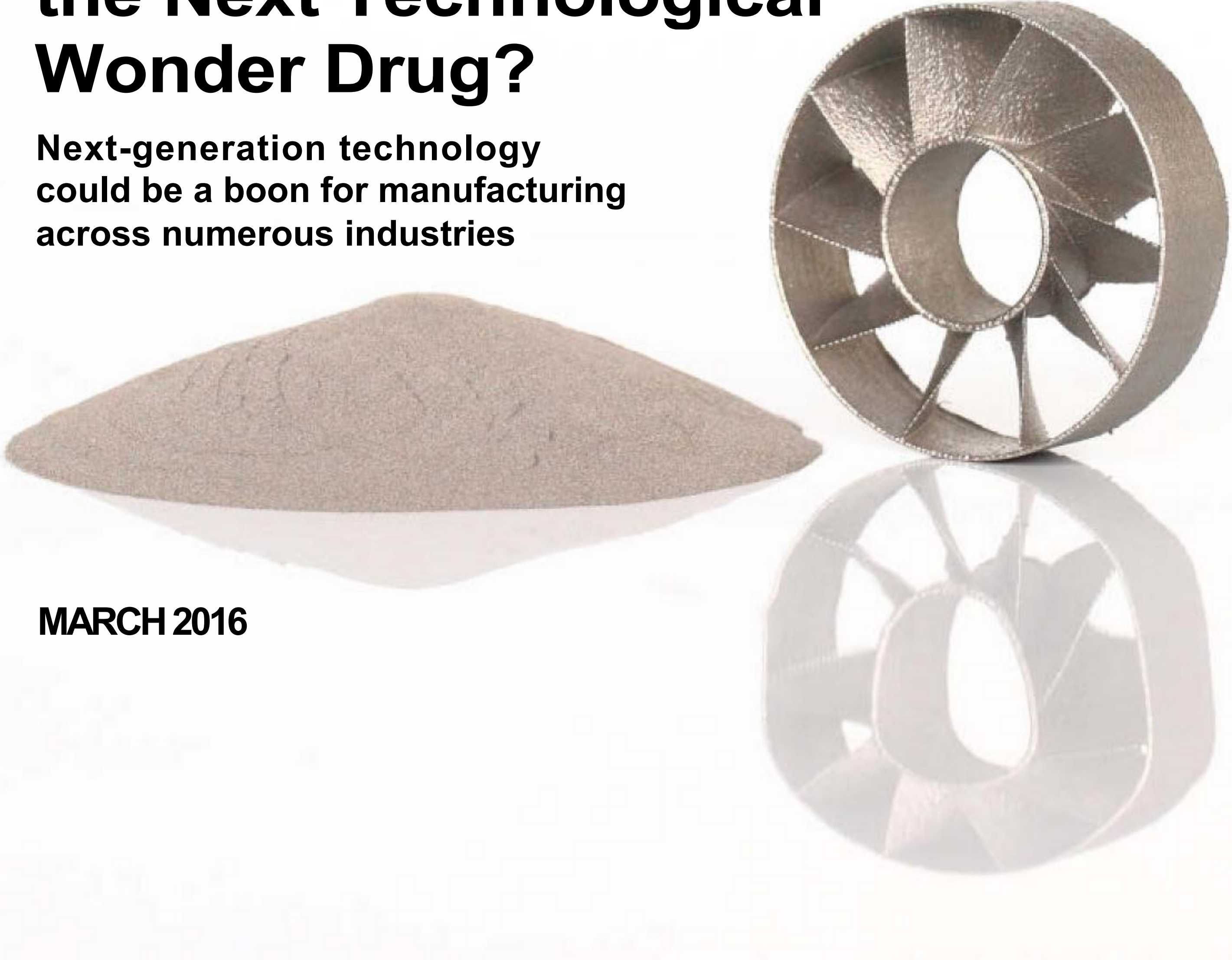
Is Additive Metal Manufacturing the Next Technological Wonder Drug?

Next-generation technology could be a boon for manufacturing across numerous industries



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IS ADDITIVE METAL MANUFACTURING THE NEXT TECHNOLOGICAL WONDER DRUG?

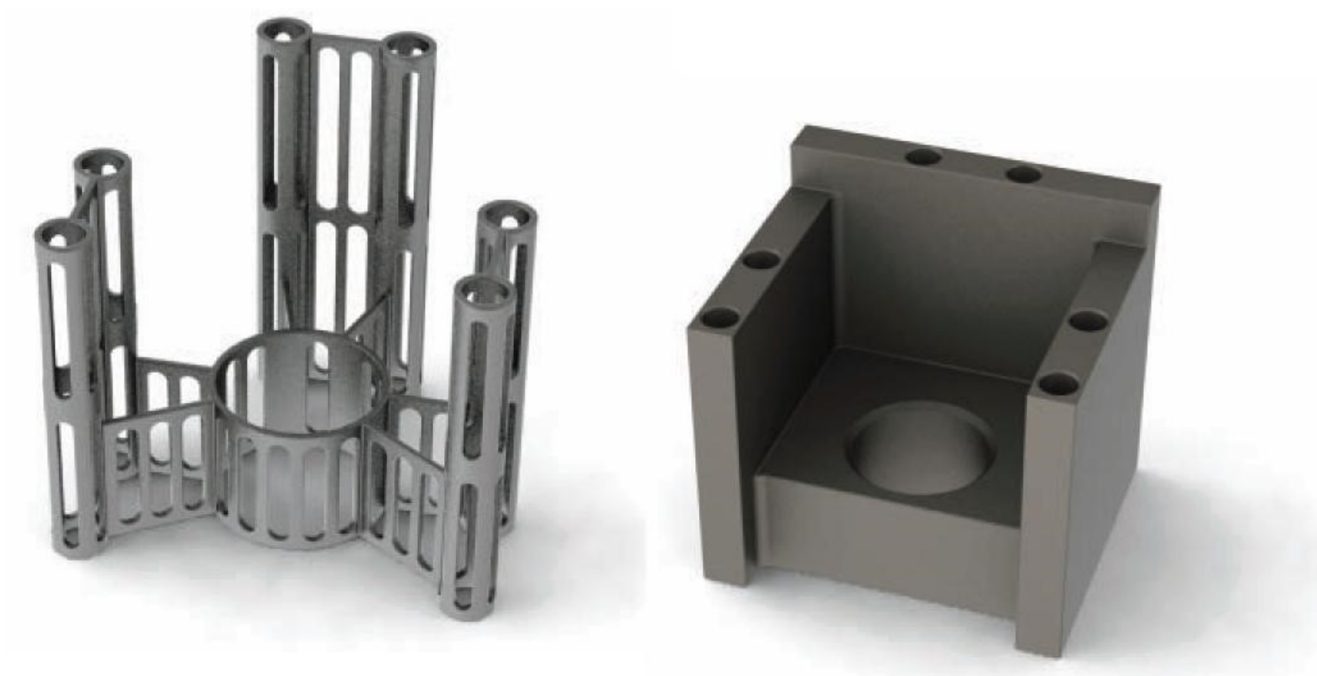
Next-generation technology could be a boon for manufacturing across numerous industries

BY NIGEL SOUTHWAY

Additive manufacturing (AM) has captured the imagination of the mainstream media who have pumped up the tires on this high-tech vehicle so much that it's almost lighter than air. The good news is that it's making many people view manufacturing in a new light, and manufacturing needs all the help it can get to have a strong and vigorous image in a society that has almost forgotten that it actually needs to make things for our economy to work for all of us.

Some of us have been manufacturing engineers for a long time and have seen and participated in the introduction of many new manufacturing technologies. All the hype makes me smile, as we have seen all this before.

Remember the buzz about lasers and how we would use them in everything we would do? We then struggled with the cost and application of the technology for two decades, and now we would not buy a machine or process without a laser to direct, control, measure, or process just about anything that needs precision and repeatability. Remember the excitement of the photoelectric cell and its younger cousin, the solar cell, and how it is now shaping and maybe participating in saving our world?



The transition to additive technology (left) from conventional machining methods means that the construction of parts can be reimagined.

And don't forget how far we have come in electronics with multilayer, flexible printed circuit boards and integrated circuits that now fuel our futures and our dreams. We now operate machine tools for sheet and tubular materials that are complex, 5-axis, computer-controlled systems using a variety of cutting, penetration, and forming media, including light beams, plasma, high-pressure air knives, electromagnetics, and waterjets for parts we would have struggled to process less than 20 years ago.

We also have robotic and custom automation workcells that weld, cut, and assemble so many of our products without the lights on that it's hard to imagine how we could be productive without them. We even have engineering and manufacturing computer systems that integrate the design processes through the build, shipping, and distribution activities.

It's always been a challenge to perfect any new technology and get people involved in the journey to embrace and assist in the introduction application and eventual institutionalization.

Additive metal technology will be just as challenging a journey for this same old reason.

THE AM JOURNEY

The metal AM journey still is in its early stages in relation to its older cousin, additive plastics technology. Currently it has a much higher initial capital cost to process parts, but offers a similar marriage of CAD and high-speed precision lasers to achieve a more rapid and flexible approach to making parts. This has changed the relationship between the product designer and the manufacturing process.

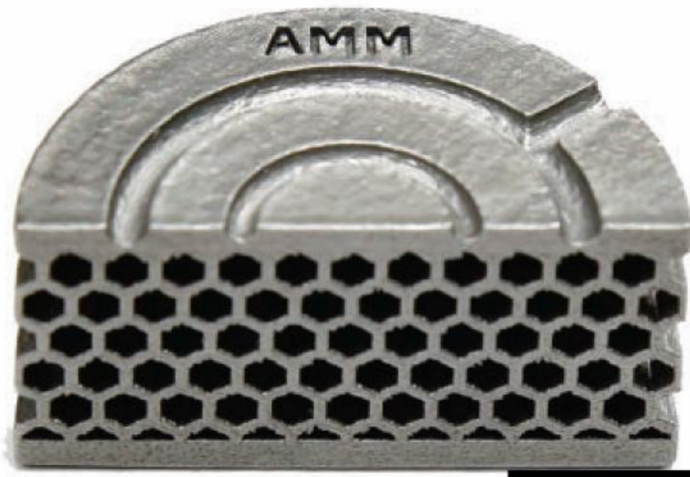
For those not manufacturing process-oriented, it looks like a magical new window into how things can be produced, but to those of us involved in manufacturing, it's a new and strong addition to our toolkit. It offers significant advantages to the product design community to develop innovative parts for next-generation products. It is unlikely to fully replace other manufacturing processes, at least for a while, but it will augment and elevate the options for manufacturing.

TAKING ENGINEERING TO THE NEXT LEVEL

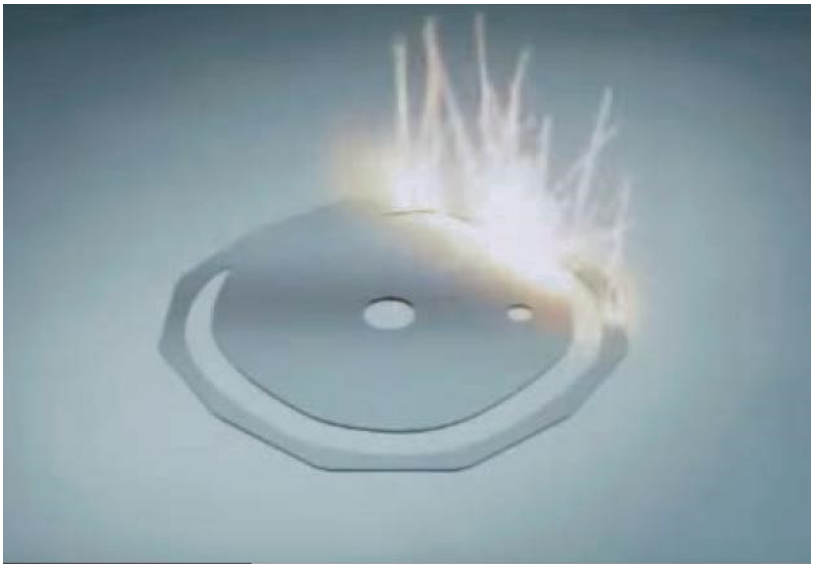
With the correct design efforts, significant "product functional" advantages that improve the mission of the product design are possible. AM will yield far less part mass with reduction factors of three or four times those of other technologies. This is because we can grow much thinner-wall structures and supports that would be difficult or impossible, and far more expensive, in subtractive technologies. Also, this work is performed without tooling or casting expenditures.

AM can liberate designers, enabling them to build in thermal management features by increasing surface area for the same part mass or topology. In addition, on the inside surfaces of parts, we can at almost no cost add features that just cannot be done in conventional machining, as well as features that most casting tooling cannot do, such as internal cooling channels and pathways.

So in a way, AM completes the journey where we can use additive plastic technology to make a mission-capable plastic part for early prototyping and then employ AM



A laser melts a layer of material that has been deposited on the build platform, fusing the powder together to make the part. More layers are applied and the melting process is repeated, creating shapes not possible with conventional machining.



In additive manufacturing, the part is "grown" layer by layer, laid down in a pattern a few thousandths of an inch at a time.

techniques to complete the production mould so that it is significantly more effective and operates at a higher performance for the final part.

For business teams, AM means quicker availability of prototype parts without tooling constraints, although some validation issues between using an additive approach and the final tool will need to be managed. In some cases, additive rapid tooling production also is possible, avoiding long delivery cycles for final, more conventional tooling. Also, when correctly applied, AM can reduce or replace expensive machining activities. It will not replace conventional machining in terms of speed and accuracy, but many applications will exist that will make AM a strong participant in manufacturing.

AM allows design engineers to integrate multiple parts into one single component rather than make and then assemble them together using conventional means. This may also eliminate assembly fit-up and integration issues associated with part interchange tolerance or, in the case of weldments, debilitating distortion caused by excess fabrication. These strategies will lead to improvements in cost, quality control, and product reliability.

WAKE UP THE DESIGNERS

Of course, all these wonderful things cannot happen without product designers understanding that these liberating options are available.

ADOPTING AM: ONE MANUFACTURER'S TAKE

As an advocate and consultant for manufacturing, and more recently AM, I have seen a huge but natural reluctance to change and adopt this new technology, and the correct personal attitudes and approaches will be just as important as the technical knowledge element. If we are to keep up with the global leaders, we need to try very hard not to be one of the following personality profiles I have run up against so far in working with prospective adopters.

Don't Be A:

- Button-pushing optimist that assumes it's going to be easy, but once it gets difficult, quickly declares AM is not for them. It's an emerging technology, so the issues will need to be embraced and jointly solved to reap its full rewards.
- Stuck-in-a-rut designer who, like a lot of engineers, won't want to bother with the riskier new technology. Unfortunately, this may become a "going out of business plan" when the competition embraces the new technology and outmodes your traditional product design performance.
- Protectionist machinist who views this technology as a threat to the status quo even if it could improve the overall part generation process. AM does not compete with subtractive machining. It provides a broader and deeper set of options for the part's design and manufacturing.
- Play-it-safe toolmaker who won't stretch outside the traditional comfort zone to design cooling channels or add features to improve tool rate or quality performance.
- Lowest-price purchasing agent who wants the lowest part price without understanding the value of AM or understanding that it's an essential developmental risk that has to be endured. Just sending a traditional subtractive-type part file to an AM provider for a quote and expecting to get a lower price from this new technology may not correctly position AM into your future business. This approach just won't work until you talk through the DFM realignment exercise with a candidate part redesigned for AM.
- R&D-averse CEO who wants it all for free or won't invest in or add development time to the product launch schedule to embed the new technology and is not prepared to encounter a learning cycle into the next product set.

The real sleeper in this game-changing technology is the product designer that we—as manufacturing engineers—have trained, brow-beaten, and shackled with design for manufacturing (DFM) procedures and check lists that talk far too much about how things "should be" and also "should not be" made, rather than thinking about the real mission of the product and part and how it could look with total freedom from DFM.

The delicate balance between design freedom and DFM rules has made designers risk-averse, and all or most of the art has been beaten out of us.

I have spent my life telling designers to be aware of DFM issues and learn about Six Sigma and how their low-score DFM designs attract adverse cost of poor quality in the manufacturing process. So should manufacturing engineers now encourage designers to let it all hang out and forget all that DFM stuff, and just design what they want, just reach out, stretch up, and put freeflow no-rules art-forms into designs?

Not quite. New metal AM DFM rules are very different and must drive designs in a completely different direction. They will demand a strong rethink and turn conventional DFM around 180 degrees.

In traditional subtractive technology, the more material we cut away or form to add features, the more expensive the part. With additive technology, the more material we add, the more expensive, and in principle most features added are free.

This DFM will be a radical change for most product designers, and it's going to take a lot more supportive collaboration between them and AM technology providers before learning cycles are completed and experiences aligned so future designs benefit from additive technology.

PROCEEDING WITH AM

The additive metal powder bed technologies, which are the central approach so far, have a significantly higher capital footprint and significantly more constraints than those enjoyed by the additive plastic technology. These constraints are mainly in the knowledge of how to process a part, the size and shape of the parts possible, the fact that more surfaces need secondary supports, and finishing. In some cases, thermal stress buildup in parts must also be managed with postprocessing.

For these reasons the best way to proceed is by partnering with an AM service provider that can consult on the AM technology and has an educational process to explain these new game-changing DFM rules. Support for the design development process and hands-on prototyping and early production capability are important too.

EVENTUALLY THE EDUCATIONAL AND INDUSTRIAL TRAINING ESTABLISHMENTS WILL BE TURNING OUT BRIGHT YOUNG MINDS IN TUNE WITH THIS NEW TECHNOLOGY.

An initial pilot project with a well-chosen candidate part always is the preferred approach, and it can become a productive learning experience for those adopting AM. Eventually the educational and industrial training establishments will be turning out bright young minds in tune with this new technology, and eventually the CAD engineering providers will develop intuitive and integrated software and learning environments for us all, but for now we must lead and learn at the same time.

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