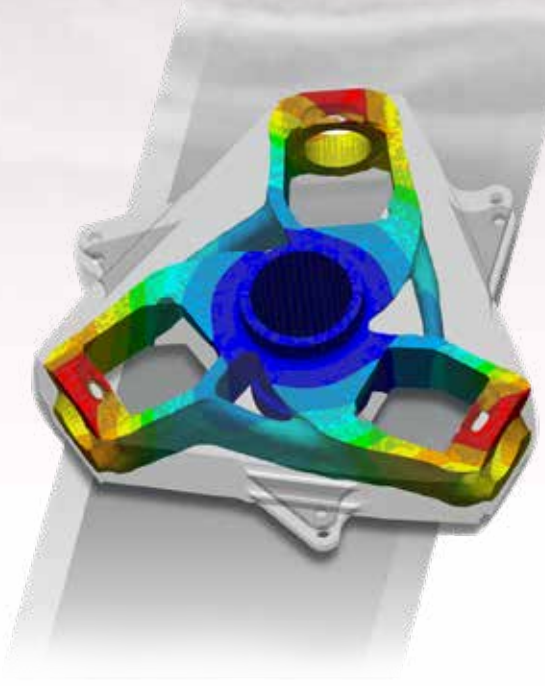
Additive Manufacturing:
A New Frontier for Simulation



ADDITIVE MANUFACTURING — popularly known as 3D printing — is poised to revolutionize both engineering and production. With its capability to quickly turn a digital design into a physical product, additive manufacturing supports mass customization and fast response times. But high materials costs require product developers to get their designs right the first time and every time. Recently, *ANSYS Advantage* discussed how simulation can maximize results and minimize risks with two ANSYS experts.

By ANSYS Staff

> **"*Additive manufacturing* should make strategic sense as part of a larger product development and manufacturing strategy."**

ANSYS Advantage: ***What exactly is additive manufacturing? And why is the business world so excited about it?***

Brent Stucker: Additive manufacturing is a technology that produces three-dimensional parts by building them up, layer by layer. It gets its name from the layers of materials that are being added — as opposed to taken away, as in some other production processes. It is popularly known as 3D printing because it involves sending a digital design to a machine that produces it very quickly.

Additive manufacturing began as a way to produce prototypes rapidly, but it is gaining broader acceptance as a final production strategy because it has many advantages over traditional processes. Obviously it allows companies to quickly progress from a digital file to a finished product. But it also enables the production of very complex shapes, as well as "one off" designs that meet the needs of a specific customer. There is also the potential to develop highly customized mixtures of materials that deliver targeted performance characteristics.

Dave Conover: Recognizing the potential of this new technology, ANSYS has developed tools for simulating metal additive manufacturing processes. We are focusing our development on metal right now, but we do plan to add more materials in the future. The reason why metal is our focus is that it is the area where our customers are investing and seeing the greatest opportunity. It is also the area where trial and error costs them the most money, and thus a metal simulation tool can have the greatest financial impact in the near term.

AA: ***How broadly is metal additive manufacturing being applied today? And what's the future potential?***

BS: Today, the early adopters of metal additive manufacturing are businesses with highly complex parts that are subject to extreme conditions — for example, aerospace companies. There is a high cost of entry for additive manufacturing, because adding new production equipment is an expensive proposition. New expertise needs to be added to the manufacturing staff. There is also a high risk associated with production failures, because metal powders and other 3D printing materials are costly.

ANSYS Topology Optimization
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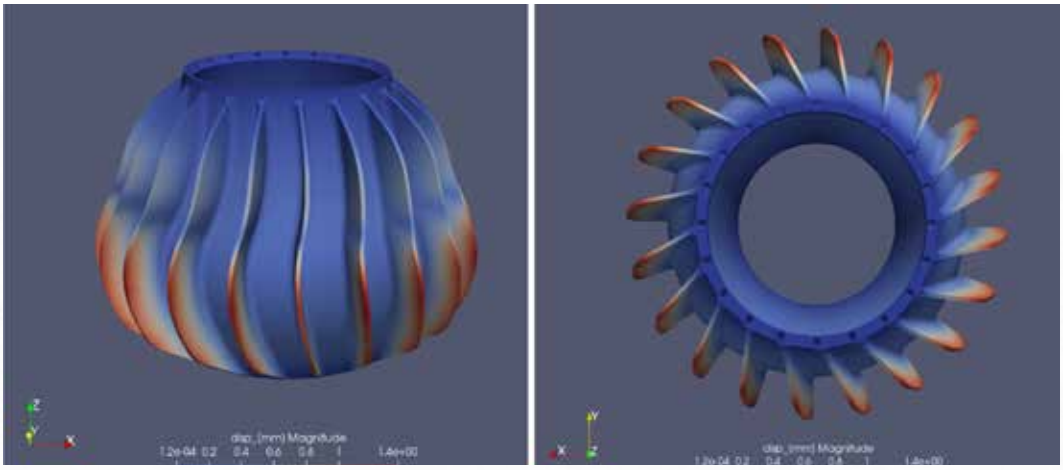

ANSYS is partnering with Renishaw, a leading engineering and scientific technology company, to understand how simulation can effectively predict stresses and failure modes during the additive manufacturing (AM) process. ANSYS Additive Print predicted that these very fine turbine blade tips — each measuring just 1.3 mm across — would deform during the high thermal stresses associated with the AM process. (The red areas designate regions of high stress.) Identifying these potential failure modes enables designers and machine operators to adjust part geometries or machine parameters to minimize the risk of costly printing errors.

DC: So it makes sense that the leaders in metal additive manufacturing are in industries like aerospace, where the benefits are great enough to make these challenges worth overcoming. But eventually, as we work together to develop solutions to these shared challenges, additive manufacturing is going to become practical for virtually any manufacturer, in any industry.

AA: ***What role can engineering simulation play in solving these challenges?***

DC: When you think about these challenges — high costs and high risk — then engineering simulation just makes sense for companies looking to explore additive manufacturing as a strategy. It makes sense because simulation has been proven, over the course of 40-plus years, to maximize certainty and minimize risk. By leveraging simulation, companies can predict whether a digital design will be produced successfully, before they metaphorically hit the "print" button.

BS: The beauty of simulation is that it can analyze the entire additive manufacturing process, from the earliest design to the finished product. Companies can not only rely on traditional simulation tools to ensure that performance criteria are met for the end product — but now they can also simulate the production process via new process simulation solutions. They can answer critical questions like, "Which machine should I send my design to?" and "Which material microstructure is the right one for this design?"

> **"Additive manufacturing means new materials, including metal powders, as well as new design and production workflows, and new physical constraints."**

AA: ***How can simulation help companies who are just beginning to explore additive manufacturing?***

BS: Just as product development teams have historically used simulation to optimize key product characteristics, specialized tools can now help them optimize their designs for the new environment of additive manufacturing. Engineers can visualize distortion and stress on a layer-by-layer basis. They can study part tolerances and build failures, which are key risks for additive manufacturing. Parts produced via additive manufacturing will have very different characteristics than cast or forged parts — and simulation helps engineers understand and address those key differences.

DC: As Brent mentioned earlier, these companies will be investing in new production equipment. Today there are specialized simulation tools that are designed to interact with these machines. Engineers and 3D printer operators can work together to identify the optimum machine and material parameters — before they try and fail. They can learn and improve continuously by comparing the predicted machine behavior, and the predicted part characteristics, with what actually occurs during printing. They can reduce printing failures and the number of prototypes required.

> **“There’s really no limit to the benefits that can be realized as additive manufacturing gains broader acceptance.”**

While additive manufacturing simulation is new, this is actually the same value proposition simulation has always offered: Minimize risk, cut time and costs, and maximize product innovation.

AA: ***What are the specific simulation capabilities that can be applied to the additive manufacturing process?***

DC: Some of the simulation functionality that applies to additive manufacturing is already in broad usage for traditional product development challenges. For example, engineers have been simulating different materials compositions for decades. They have been optimizing their products’ topology and manipulating geometry to optimize both production processes and performance in the field. They have been conducting thermal and structural analyses. Engineers have also historically studied part shape, distortion and stress. What’s exciting today is that there are new, specialized tools that consider all these aspects in light of the unique conditions of additive manufacturing, or 3D printing. Additive manufacturing means new materials, including metal powders, as well as new design and production workflows, and new physical constraints. But ANSYS makes it easy to accommodate these changes by offering a new generation of solutions that are an extension of the capabilities in our traditional software suite.

BS: Equally exciting are brand new software tools that have been created specifically to optimize the production of engineers’ designs on today’s state-of-the-art additive manufacturing equipment. For the first time, ANSYS has developed simulation software specifically for machine operators. These production experts can accurately build the design in a virtual environment, increasing confidence that a specific product geometry will print optimally on a specific additive manufacturing machine. This software interacts with traditional design software and can operate independently or as a part of the ANSYS technology platform, ensuring a closed-loop design-and-build cycle that maximizes successes and minimizes failures. (Editor’s note: Learn more about specific ANSYS solutions for additive manufacturing on page 19.)

AA: ***Why has ANSYS made the decision to invest in new solutions that are specific to additive manufacturing?***

DC: Today, the traditional boundaries between functions are disappearing as it becomes possible

The ANSYS Vision for Simulation-Driven Product Development in Additive Manufacturing
ansys.com/am-vision

Courtesy Renishaw

For a single turbine blade, ANSYS Additive Print proved extremely accurate in predicting deformation during the AM process, when compared to an actual print run. By compensating for the stresses identified by ANSYS Additive Print, the final part was extremely close to the desired geometry. Without compensation, the part would have been considered a failure, resulting in wasted time, equipment capacity and materials costs. ANSYS has estimated that, for complex geometries such as turbines, a single failed print run could mean tens of thousands of dollars in wasted costs.

to design something and produce it quickly. To take advantage of these kinds of technology breakthroughs, the whole company needs to collaborate much more closely — and emerging simulation solutions facilitate that. ANSYS has new tools that can be used by different functions within the business, including production operators and materials engineers, but they are united by one technology platform.

ANSYS feels a real responsibility to monitor industry trends and help our customers capitalize on new opportunities like additive manufacturing that can add value — not just in the engineering function, but across the company. It is just one more aspect of our commitment to pervasive simulation.

BS: It is impossible to overstate the impact additive manufacturing can have on a traditional manufacturing company. This technology is a game-changer. Medical devices can be produced with patient-specific geometries. Huge spare parts inventories? Those will be a thing of the past, as replacement parts can be produced when they've been ordered. Products that operate in extreme environments, such as in the oil and gas industry, can be produced with new hybrid materials compositions that take their durability to a new level.

There's really no limit to the benefits that can be realized as additive manufacturing gains broader acceptance. It's going to increase collaboration across the company — driving out time and costs from the design-and-build cycle — while giving engineers new freedom to create and deliver highly innovative products. In the next five to 10 years, additive manufacturing is going to become a competitive imperative, and companies that don't adopt this practice will be left behind.

> **"ANSYS has developed tools for simulating metal additive manufacturing processes."**

AA: ***How can companies begin to adopt an additive manufacturing strategy?***

BS: One of the most common misconceptions is that additive manufacturing is an "all or nothing" proposition. I think companies are discouraged by the prospect of replacing all their production equipment with new additive manufacturing technology. But that's simply not the case.

Few products are manufactured, start to finish, via additive manufacturing. Instead,

key components are 3D printed, then assembled with traditionally produced components to form products that represent the best of both worlds. So traditional manufacturers can begin by asking, "What parts of my products lend themselves to additive manufacturing?" These might be parts with complex geometries, those subjected to special stresses, or those with a high level of customization.

Additive manufacturing should make strategic sense as part of a larger product development and manufacturing strategy that also includes traditional manufacturing capabilities.

DC: Similarly, companies should begin to add simulation capabilities specifically developed for additive manufacturing that integrate seamlessly with their existing simulation portfolio. They should consult with experienced partners like ANSYS about how they can leverage simulation in a targeted way to begin to enter the realm of additive manufacturing, at a relatively low level of risk and investment.

> **"While additive manufacturing is a relatively new technology, best practices already exist."**

While additive manufacturing is a relatively new technology, best practices already exist. ANSYS has worked with the earliest adopters — and can help new adopters implement those practices in a way that makes the best sense for their own business model.

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