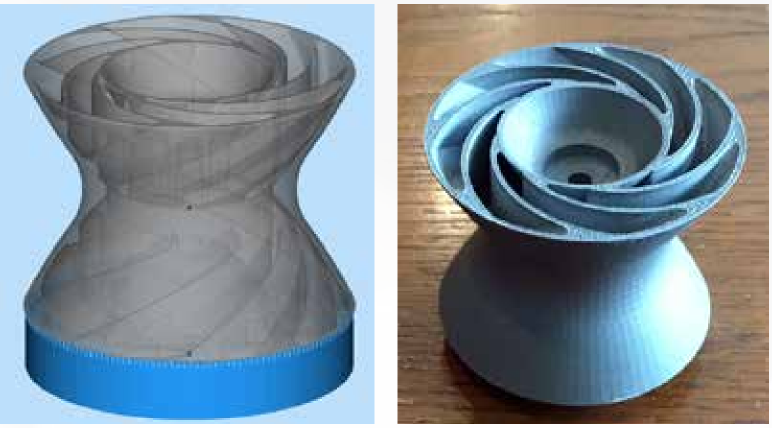
Getting Metal 3D Printing Right the First Time with ANSYS Additive Print

As the benefits of additive manufacturing become increasingly apparent, organizations are seeking ways to improve processes for 3D printing. ANSYS channel partner PADT has long been in the forefront of additive manufacturing as part of a broad range of services for rapid prototyping. The PADT team has recently been working with ANSYS Additive solutions to ensure that customers can quickly receive additively manufactured parts that are viable immediately.

By **Eric Miller**, Principal and Co-Owner, PADT, Inc., Phoenix, USA

Metal additive manufacturing is one of the fastest growing sectors of manufacturing. According to the Wohlers Report, 2017 saw an 80 percent growth in metal system sales. Companies across industries want to leverage the speed and flexibility of 3D printing to create their metal components. The most common process is to build metal parts layer by layer with laser powder bed fusion during which a laser melts powdered metal, then that metal solidifies. However, this creates thermal stresses, and thermal stresses create distortion. The result, at best, is a part that does not match the CAD model within acceptable tolerance. At worst, because distorted parts interfere with the machine during printing, very costly machines can be damaged when the powder-smoothing blade hits portions of the parts that protrude from the powder.



ANSYS Additive Print confirmed that no additional supports were required for this part for a small gas turbine. The manufactured item verified the correctness of the part.

PADT purchased its first 3D printer almost 25 years ago and has been adding machines ever since. Six different additive manufacturing technologies in this area are offered to customers, and hundreds of parts are processed per month. PADT has been running one of the newer technologies, laser powder bed fusion for metals, for over a year. During that time engineers have viewed residual stress deflection issues firsthand. Some parts are not badly distorted, but others curl up like potato chips. In most cases, the team designs thin metal structures as supports under overhanging features to hold the part down until it is heat treated to alleviate those stresses. But PADT was only speculating on what supports were necessary and often overdesigned them. The team now uses ANSYS Additive Print to optimize supports, compensate for distortion and avoid blade crash. It has been a real time saver.

The team first used ANSYS Additive Print on a part from a customer, Monarch Power Corp., which is developing innovative solar-powered products so that people can generate their own power. One of their new products is a small gas turbine with a centripetal spiral vane compressor, internal combustion chamber and centrifugal spiral vane expander. It is ideal for additive manufacturing because all these elements can be printed together along with a built-in axial flux electric generator. It is self-supporting, there is no overhanging geometry, and the outside surface holds all the internal geometry in place, so it only needs supports on the bottom of the part. ANSYS Additive Print predicted minimum distortion and no need for supports. Following the recommendations of Additive Print, PADT built the part with no supports. The actual build verified the ANSYS model. PADT saved the customer time and materials by avoiding over-constraint of the part by unnecessary supports.

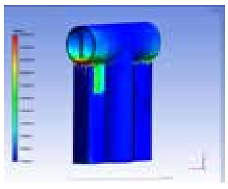
When designing a T-tube for additive manufacturing, the alternative to simulation is trial-and-error, which would have led the team to the same conclusion after spending several weeks and tens of thousands of dollars in printing, post-processing and engineering expense. Trial-and-error also results in wasted metal and damaged powder blades. PADT was easily able to verify that the model was good in the turbine model, and then determine the geometry to correct printing errors for the T-tube.

The simulation process was simple and intuitive, and a manufacturing intern did all the modeling in ANSYS Additive Print. Additive Print will be part of future metal 3D printing projects to save iterations and material, and deliver accurate final parts to PADT customers sooner. ∧

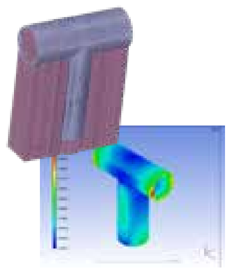
The work mentioned in this article was done by Paraic O'Kelly and Anna Hayes in PADT's Manufacturing Technology department.

ADDITIVE MANUFACTURING OF A T-TUBE

The team decided to really put ANSYS Additive Print to the test by simulating and manufacturing a T-tube model that PADT has been making for decades, to test support structures and accuracy for plastic and metal 3D printing.



After generating supports using PADT's standard 3D printing pre-processing tool, the team performed a quick assumed strain analysis in Additive Print and determined that the model was not being held properly. The first layers at the bottom of the horizontal tube distort significantly so that if the part had been printed, the layers would probably pull off the support and crash the machine.



PADT staff used ANSYS Additive Print to design the supports. The software predicted a distortion of 0.4 mm vs. the 3.0 mm with the standard supports.

The distortion compensation capability in ANSYS Additive Print was then used to calculate local distortion and modify the geometry so that the final printed shape would be even closer to the desired dimensions.

The part (including the supports) was printed in 17-4PH stainless steel on a Concept Laser MLab laser powder bed fusion system.

Using a ZEISS structured light scanner, the PADT scanning team inspected the part with the supports removed. The measurements revealed approximately a 0.38 mm deviation from the nominal CAD model, which, for a part with this much distortion potential, was very good.

When the scan results were compared to the final geometry, it was revealed that the surface roughness from the support material removal is the cause of most of the deviation, not thermal distortion. In areas away from the surface roughness of the support attachments, the distortion is only about 0.13 mm, showing that the optimized supports and distortion compensation from ANSYS Additive Print produced a final printed part well within acceptable tolerances.

The printed part >