Pounding Metal Parts into Profit

A novel additive manufacturing technique combines metals and embeds sensors

A burst water main is always a mess, but a pipe that fails in space can be mission-ending. That's why NASA technologists must make hardware as reliable as possible.

This challenge spurred Scott Roberts, a technologist at NASA's Jet Propulsion Laboratory in Southern California, to turn to a new kind of welding in the 3D printing industry. He thought ultrasonic additive manufacturing could improve spacecraft components' reliability. Now one company that used the technique to build parts for Roberts is manufacturing parts for industries from aeronautics to oil drilling.

What does 3D printing have to do with pipes? Temperature is a problem in space, where extremes vary by hundreds of degrees. Heat exchangers help spacecraft maintain a steady temperature by removing excess heat or drawing in more. They normally have many parts, introducing numerous potential points of failure. Small Business Innovation Research (SBIR) funding from JPL let Columbus, Ohio-based Fabrisonic LLC take a new approach to building a heat exchanger. The company started with its existing process, which uses high-frequency vibrations to fuse together multiple thin layers of metal. To create the heat exchanger, a curved channel was carved into the layered metal and then enclosed under additional layers.

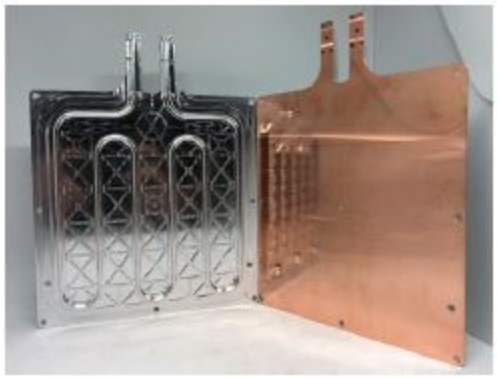
How can vibrations fuse metal? Ultrasonic welding uses constant pressure and ultrasonic vibrations to cause friction between layers of metal, raising temperatures and removing surface oxides to allow direct contact between surfaces. The result is an atomic bond that welds the layers together. Even different metals can be bonded together. Ultrasonically manufactured pieces can be as large as six feet square, have complex geometries, and be produced in a matter of days, not months.

Why combine different metals? Protecting electronic components from space radiation that can destroy them is challenging when everything on a spacecraft needs to be lightweight. Additional SBIR funding provided by NASA's Langley Research Center in Hampton, Virginia, paid for Fabrisonic to add layers of radiation-resistant tantalum in the middle of aluminum spacecraft parts. Customers in the oil and gas industry use this process for making well drill pipes – hollow, thin-walled tubing that combines dissimilar materials and uses embedded sensors.

Why put sensors inside metal? Fiber-optic sensors can detect metal strain or weaknesses and predict possible failures. Other SBIR funding from Langley helped Fabrisonic test the effectiveness of sensors built into aluminum parts. The company found that the sensors, protected within metal, can function in harsh environments like the Oak Ridge National Laboratory, which researches energy and nuclear science. In NASA aeronautics testing, the sensors helped detect weaknesses and performance issues in commercial airframes.

What if I want to print small parts myself? SBIR funding from NASA's Marshall Space Flight Center in Huntsville, Alabama, let Fabrisonic explore advanced metals and ultrasonic welding for in-space manufacturing. NASA engineers helped the company create the key component of a small ultrasonic printer – the weld head that transfers vibration onto the device's metal tape. Commercial sales of the resulting SonicLayer 1200 printer have generated $1 million in revenue, with one customer producing over 70,000 parts. ●

CubeSats can be used for a variety of tasks, from Earth observation to flying science experiments, but their small size makes it a challenge to assemble all the parts as well as shielding needed to manage the extreme temperatures of space. NASA is interested in new manufacturing techniques that enable more efficient use of materials. *Credits: NASA*



This 3D-printed radiator for a CubeSat combines aluminum and a small bit of copper to allow heat to spread more evenly across the face. Fabrisonic was able to combine the metals using additive manufacturing techniques that employ ultrasonic welding. *Credit: Fabrisonic LLC*