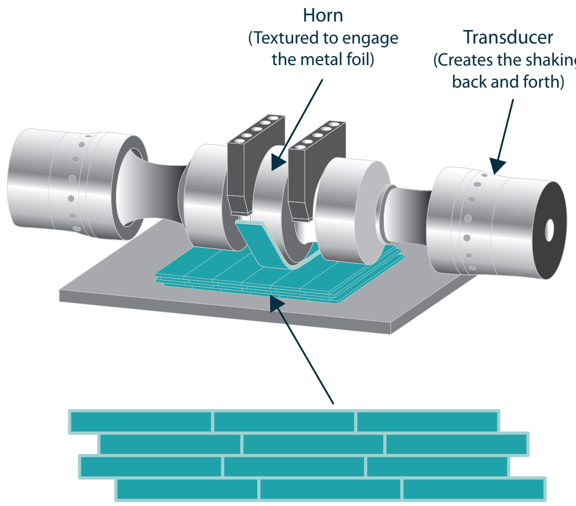
Complex Internal Geometry

HOW IT WORKS: 3D PRINTING WITH SOUND

Ultrasonic Additive Manufacturing (UAM) is a 3D metal printing technology that lets you embed electronics and sensors into metal parts of any design. The process uses ultrasonic sound waves to merge layers of metal foil together in the solid-state; there is no melting of the metals. The process produces true metallurgical bonds with full density and works with a variety of metals including aluminum, copper, stainless steel, titanium, and more. Dissimilar metals can be printed together due to the low temperature welding process.

Computer Numerical Control (CNC) machining is used interchangeably with foil layering to introduce internal features along the way and for part finishing. By combining a hybrid system, with both additive and subtractive processes, UAM can build complex internal geometries considered impossible to replicate with conventional manufacturing. For example, complex chemical reaction chambers with embedded controls can be easily printed with UAM.



3D PRINTING HEAT EXCHANGERS

Heat exchangers play a vital role in the performance of a wide band of industrial components in electronics, aerospace, power generation, and modern manufacturing. Increasingly, there is a need for high performance thermal management devices that can pull heat out of smaller and smaller areas at higher and higher rates. The push for increased efficiency of traditional thermal management devices has brought forth the need for designs only possible through 3D printing. Additive manufacturing is uniquely enabling to heat exchangers in that allows:

- *Complex channel path designs* – Historically, specialty heat exchangers are made using traditional CNC machining to create planar arrays of cross drilled holes. This limits the shape of the internal passageway where 3D printing now allows internal geometries to be fully optimized for localized thermal performance per any application.
- *Consolidation of multiple components into a single part* – Traditionally, more complicated thermal devices are made using a series of connected machined

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components joined via brazing or diffusion bonding. However, these additional steps are expensive, time consuming, and undesirable on the production level. 3D printing removes all connections allowing for uniform thermal expansion and removal of problematic joints.

- *Higher performance* – In most traditional production methods, air gap, material selection, and channel sizes can never be fully optimized. However, using processes like ultrasonic additive manufacturing, multi-materials can be selectively mixed to optimize thermal performance while also removing air gaps and breaking the limitations of traditionally machined heat exchangers.

- *Waste reduction* – Material can be selectively added to build net shape prior to final machining to final specifications as opposed to traditional machining of a billet where a large portion of the material is removed when creating channels.

WHY UAM

Compared to powder 3D printing processes, UAM is uniquely enabling because of the mechanism used to build up material. UAM enables mixing and matching dissimilar materials within a part to achieve both optimized thermal performance as well as optimized mechanical and weight requirements. Selective additions of copper within an aluminum part can significantly boost thermal performance without having much effect on mass. Dissimilar metals can be built or solid tubing can be pressed into machined channels to meet corrosive requirements when needed. UAM allows embedding sensors and electronics into parts. Heat exchangers have been produced with thermocouples embedded in the solid metal where they are safe from corrosion but allow access to data points not typically accessible. Fabrisonic has also embedded pressure sensors, monitoring circuits, and even spring/ball combinations for integral check valves further pushing the limits of 3D printed heat exchangers.

In aerospace aluminums, Fabrisonic has built thermal management devices with burst pressures in excess of 6000 psi with hermetic seals tested to have helium leak rates of 8.0E-10 cc/s. UAM has been used to produce thermal management devices with channels sizes that range from the micro-scale (~0.010") to macro scale (>0.500"). Using a combination of milling techniques, complicated structures with micro-channel cooling loops can be built with integral macro-scale headers without the issue of extracting powder from problematic geometries. Additionally, because UAM machines are based off commercial 3-axis CNC mills, they can achieve the same surface finish and tolerance as traditional CNC machining easily allowing UAM heat exchangers to replace current lower performance heat exchangers in service.

To read more about complex internal geometry, go to our website **www.fabrisonic.com** or visit **http://youtu.be/saSrmgEZJzM** to see our process in action.