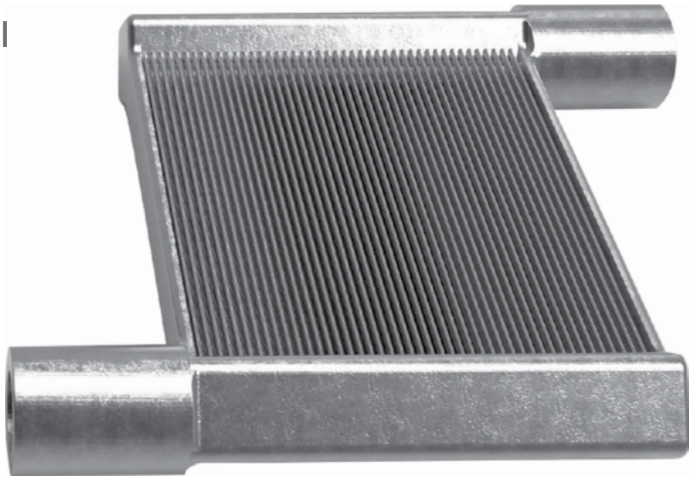
Direct metal printing (DMP) enables CEEE to manufacture lean and green heat exchanger with 3D Systems On Demand Manufacturing Services

The University of Maryland's Center for Environmental Energy Engineering (CEEE) sums up its quest to deliver innovative approaches to energy conversion in two words: lean and green.



CEEE is working with Oak Ridge National Laboratory to develop the next generation of miniaturized air-to-refrigerant heat exchanges for HVAC and refrigeration applications. For this project, funded by the US Department of Energy's Building Technologies Office[1], only one type of manufacturing could satisfy CEEE's lean and green mandates: direct metal printing (DMP) using 3D Systems' Quickparts service.

Greater efficiency in less time

CEEE provides innovative solutions and technology transfer to meet industrial research and development challenges. Sponsors are leading industrial companies and government agencies that pool research funds to augment direct support from the University of Maryland.

3D Systems On Demand Parts, Quickparts, is the world's leading provider of unique, custom-designed parts, offering instant online quoting, expertise in 3D design and printing, and proven manufacturing services support.

CEEE and Quickparts teamed to increase the efficiency of a 1kW heat exchanger by 20 percent while reducing weight and size. The manufacturing cycle for the heat exchanger was reduced from months to weeks.

Making it manufacturable

Heat exchangers are found in modern economies across the world. Any time heat, cool air or refrigeration are required, a heat exchanger is likely involved. On a global scale, heat exchange is a multi-billion-dollar industry touching everything from consumer goods to automotive and aerospace engineering.

CEEE's extensive experimental and theoretical research has led to automated design algorithms for creating unique shapes for tubes and fins used in heat exchangers. The goal is to reach an optimal air-side thermal resistance and minimize the size and weight of the heat exchangers. But, these innovative designs require new ways of manufacturing, according to Vikrant Aute, director of CEEE's Modeling and Optimization Consortium.

"Most of these optimized designs are simply not economically manufacturable today," says Aute. "They are too complex technically with small feature sizes and extremely thin material thicknesses."

That's where the unique capabilities of direct metal printing come into play. With DMP, complexity is free — it costs no more to create a highly complex design than it does a more simplistic one.

DMP, in this case 3D Systems' ProX™ DMP 320 system, enabled CEEE to prototype its heat exchanger with non-conventional, variable shapes that are not possible to manufacture using traditional forming techniques such as extrusion or stamping.

"DMP allowed us to manufacture highly unusual tube shapes in the form of a hollow droplet to carry the refrigerant," says Aute.

[1] US-DOE Project: http://energy.gov/eere/buildings/downloads/miniaturized-air-refrigerant-heat-exchangers
CEEE: www.ceee.umd.edu
ORNL: www.ornl.gov

Quickparts provided input into the design of the heat exchanger to ensure that it could be manufactured efficiently.

“The ProX DMP 320 allows us to deliver open-channel diameters and feature sizes as small as 250 microns in a reliable and repetitive way,” says Jonathan Cornelus, business development manager at Quickparts. “High pressure and leak tight exchanger walls can be built as thin as 200 micrometers, which is a true game-changer for heat-exchanger applications.”

Better design in one part

Working together, CEEE and Quickparts optimized the heat-exchanger design so it could be printed as a single part that requires minimal secondary finishing operations. Manufacturing can be completed in weeks instead of months, enabling CEEE to test designs much earlier and more often during the research program. The one-part design also helps ensure greater reliability.

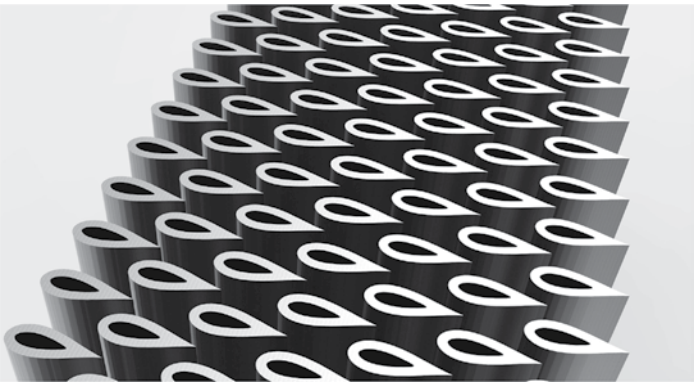
“With conventional manufacturing technologies, assembly by brazing extremely thin tubes to a manifold is a painstaking operation with very low reliability when it comes to leakages under high-pressure conditions,” says Aute. “With DMP technology, no assembly is required since the part is produced in one continuous operation, no matter how complex the parts or how delicate the features.”

Besides the ability to handle very complex parts at no extra cost, the ProX DMP 320 offers other advantages that fit into CEEE’s lean and green scenario.

Preset build parameters, developed by 3D Systems based on the outcome of nearly half-a-million builds, provide predictable and repeatable print quality for almost any geometry.

A totally new architecture simplifies set-up and delivers the versatility to produce all types of part geometries in titanium, stainless steel or nickel super alloy. Titanium was chosen for the CEEE heat exchanger project, based on its lack of porosity and the ability to provide extremely thin, but very strong, walls.

Exchangeable manufacturing modules for the ProX DMP 320 system reduce downtime when moving among different part materials, and a controlled vacuum build chamber ensures that every part is printed with proven material properties, density and chemical purity. The small portion of non-printed material can be completely recycled, saving money and providing environmental benefits.



CEEE performed extensive testing on the new heat exchanger design, using infrared cameras to verify that heat was dispersed uniformly over the exchanger and that all the narrow, droplet shaped exchanger channels were open and functioning fully. Results showed that the DMP-manufactured heat exchanger performed as expected.

Adding mean to lean and green

The unique capabilities of direct metal 3D printers such as the ProX line is rapidly turning DMP from an experimental prototyping tool into a mainstream production asset for manufacturers worldwide.

“We are witnessing new applications and massive improvements for existing projects in upper-end aerospace and industrial equipment markets, especially in cases where reduced space, low weight and high efficiency are critical concerns,” says Quickparts’ Cornelus.

“CEEE’s heat-exchanger application exemplifies the importance of DMP in the lean manufacturing space for creating low volume, high-complexity metal components. These parts are now performing critical functions under challenging conditions such as continuous stress, high pressure, repeated use and extreme temperatures.”

Considering the strength and reliability that defines DMP manufactured parts, perhaps it’s appropriate to add “mean” to the virtues of lean and green. That trio of attributes fits very well in rapidly evolving manufacturing environments where one size rarely fits all and the need for speed is paramount.

3D Systems Corporation
333 Three D Systems Circle
Rock Hill, SC 29730
www.3dsystems.com