Ultra-compact heat exchanger fabricated by 3D printing

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Awards: Red Dot Award: Design Concept 2022

Red Dot Award:

The Red Dot Design Concept Award focuses on design concepts, ideas, and visions. The competition invites young, up-and-coming creative talents, designers, design studios, companies, and universities around the world to challenge the status quo and present the most exciting design ideas to international experts from various fields. This year (2022), the award is only given to 9 % of the entries.

Introduction:

Heat exchanger (HE) is a key component in the solar thermal system, which is claimed to be one of the most efficient systems to harvest solar energy as the renewable energy source. Traditional design and fabrication method for HEs suffer from low heat transfer efficiency and leakage due to the traditional design and assembly error constrained by the traditional manufacturing process. They are unable to handle the growing thermal loads in the confined space.

In response to these problems, the team led by Professor SONG Su developed an ultra-compact heat exchanger enabled by laser 3D printing technology. It employs the mathematically perfect Triply Periodic Minimal Surface (TPMS) structure in the heat exchanger design, which has the unique properties of high surface-area-to-volume ratio and smooth and intertwined fluid channels in 3D space. Through coordinate transformations and implicit design using geometric formulations, they successfully realized the conformal filling of the TPMS structures into the freeform heat exchanger design. This method dramatically improves the heat exchange efficiency and reduces the fluid pressure drop. Moreover, they achieved different product designs through filling different TPMS structures and the conformal transformation to meet the needs of different working conditions, thereby alleviating the problem of huge energy lost in the traditional heat exchanger. Due to its unique internal TPMS structure and integrated one-piece design, this heat exchanger will be very durable and highly efficient, which also reduce the maintenance cost.