Development of additively manufactured miniature heat exchangers

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Development goal

The main objective was to develope a compact and efficient heat exchanger, reaching higher thermal power compared to conventional heat exchangers.
Therefore the possibilities of additive manufacturing have been taken into account:

- High heat exchange rate – no loss by joining surfaces
- Compact and lightweight design
- Shape can be specifically adapted to customer requirements and available installation space

A new concept for heat exchangers

As part of initial concept developments, some new profile geometries had been considered. The profiles, shown in Fig. 1, had been investigated for their thermal power and pressure loss, using the same boundary condition for each case. CFD simulation results have revealed the optimization potential.

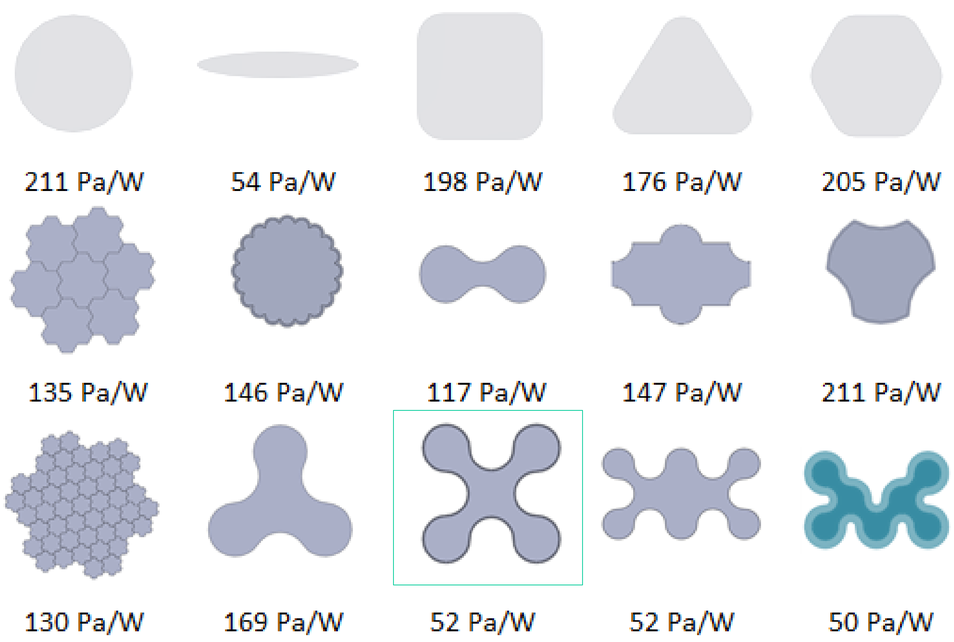

Fig. 1.: Summary of the investigated profile geometries, showing the pressure loss per thermal power

The development of an innovative profile geometry required a new inlet and outlet design, inspired by natural bionic structures (Fig. 2), followed by the design, CFD simulation and manufacturing of the heat exchangers (Fig. 3).

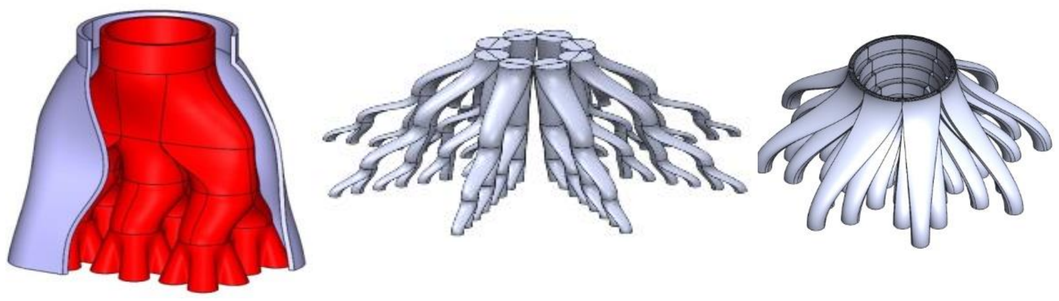

Fig. 2.: Images of developed inlet and outlet designs

Development process

- Modular heat exchanger geometries
- Wall thickness: 0.3 mm

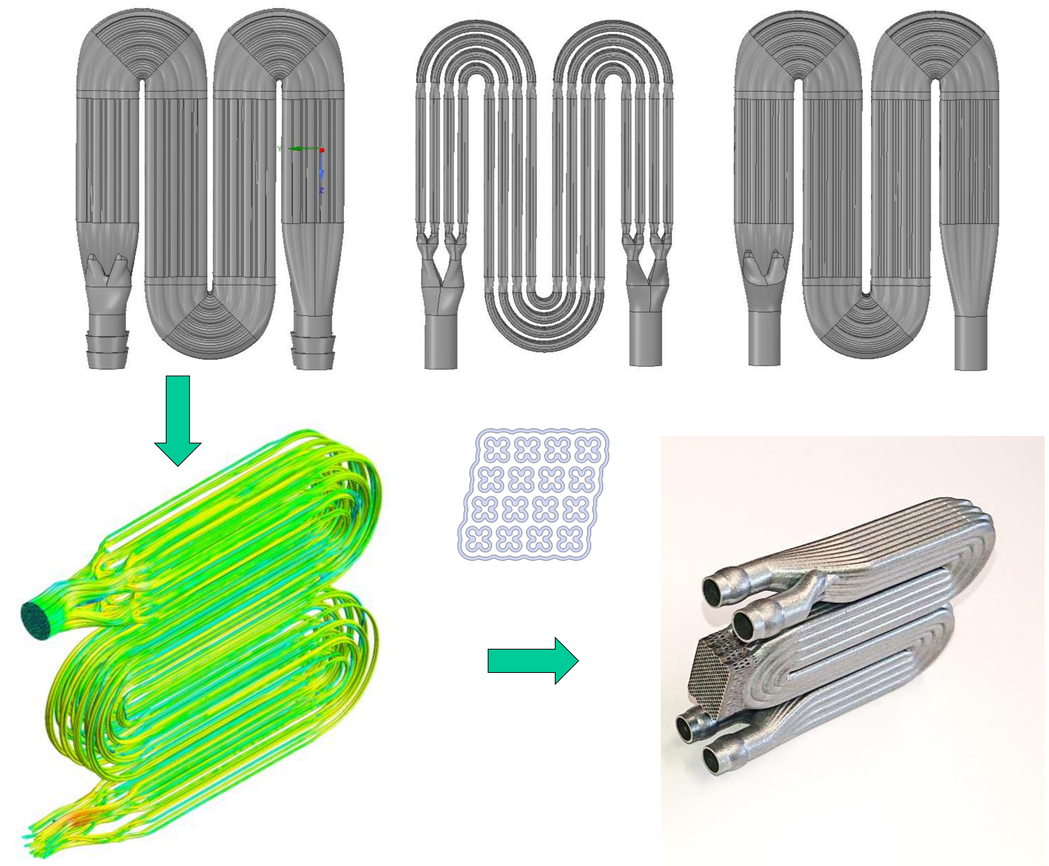

Fig. 3: Development process of additively manufactured miniature heat exchangers

Experimental validation

The experimental tests, using water as fluid, were implemented by a dedicated test stand. The applied boundary conditions and results are shown in Fig. 4.

- $\dot{V}_{cold} = 1{,}9\ \mathrm{l/min}$
- $T_{cold} = \sim 13\ °\mathrm{C}$
- $\dot{V}_{hot} = 1{,}6\ \mathrm{l/min}$
- $T_{hot} = 50\ °\mathrm{C}$
- Thermal power (M-shape): 2352 W

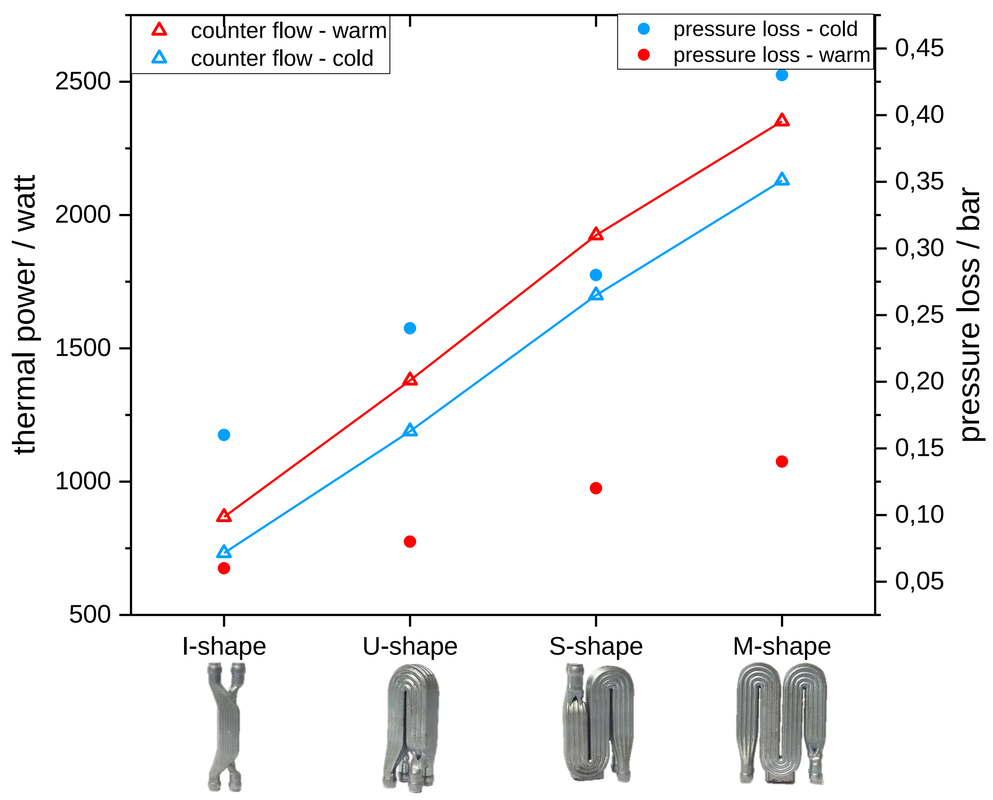

Fig. 4: Summary of results, showing the thermal power and pressure loss, depending on the geometry (I-, U-, S- and M-shape)

Improvements in performance

- Compactness up to 1642 m²/m³ (conventional: ~ 600 m²/m³)
- Capacity per Volume: 113 W/cm³ (conventional: 12,5 W/cm³)

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