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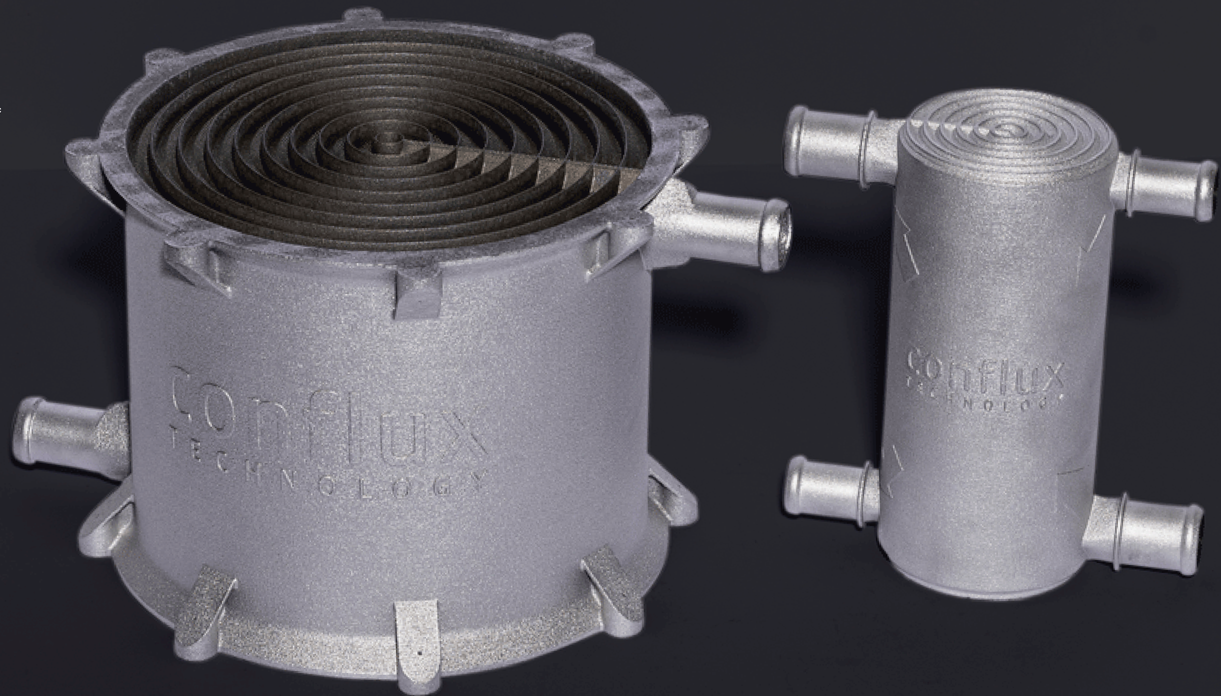
CASE STUDY

Annular heat exchangers - cutting-edge technology

RESULTS SUMMARY: ANNULAR WCAC*

- 15% smaller core volume
- 24% reduction in air-side pressure drop
- 39% reduction in wet weight
- 31% reduction in dry weight

*benchmarked against leading microtube WCAC



A new paradigm

Conflux Technology continues to pioneer thermal technology with our annular – or ring-shaped – ultra-high performance heat exchangers. Overcoming a multitude of design and manufacturing challenges, the Conflux team have developed a new foundational heat exchanger design.

The various annular ring applications are now well positioned to outperform anything currently on the market.

ROUND OF ADVANTAGES

Round shapes are better at evenly distributing pressure, so the structure of these heat exchangers enables them to excel in extreme conditions and provides the basis for standardised designs that enable rapid configuration and deployment.

The channel heights can easily be adjusted whilst sizing the exchanger (e.g. lowering resistance to flow or pressure drop, etc.), providing flexibility in meeting different boundary conditions and, consequently, servicing myriad applications such as aerospace, marine and motorsport.

The ability to change surface area density by adding or subtracting fin and mixing structures within the channels allows us to finetune the performance and, as the piping that supplies fluid into the heat exchanger is circular, an annular design is a hand-to-glove fit for evenness in the flow throughout the exchanger.

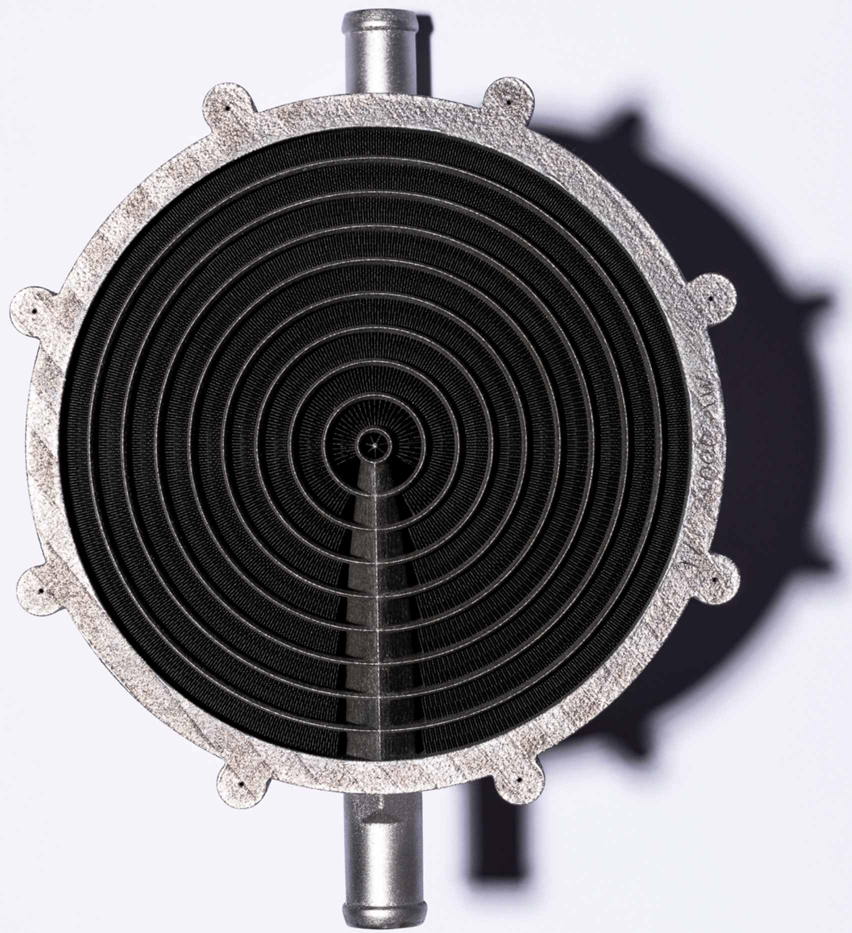
Challenge: Create the ‘elite’ of heat exchangers

THINNER, LEANER, HIGH-PERFORMING

Heat exchanger performance improves with thinner walls. Thin walls allow the surface area to be increased without increasing blockage, or to maintain surface area and reduce part size without increasing pressure drop. Thin walls also mean lower part mass, a critical consideration for many of our customers.

The previously market leading microtube design for heat exchangers features thousands of tubes with walls a fraction of a millimetre thick. Thanks to advances in laser bed powder fusion (LPBF), a type of metal 3D printing, we believed the same performance could be realised using additive manufacturing.

We tackled the challenges for creating our annular heat exchanger and found various means for overcoming them.



Design: Scaling tiny components

CHALLENGE

The annular heat exchanger needed to be adjustable to meet the varying boundary conditions of different clients. We had to find a way to develop manifolds that could distribute the fluids evenly from single inlet connections to the many ring layers leading into the core.

We also needed to attend to all of this in extremely fine design detail, which resulted in CAD files so large they would invariably crash our computers and take as long as five days to print.

SOLUTION

Through innovative CAD modelling, we deployed a parametric modelling approach to the design process that allowed adjustment according to a clients' boundary conditions and packaging requirements and enabling rapid configuration.

We used concentric layers of channels alternating between cold and hot. We also came up with a unique, highly efficient manifold for delivering fluid into the core in a very even flow distribution that eliminated 'dead zones'.

A bespoke and streamlined methodology for handling the large files allowed us to work around the limitations of our CAD programs, simultaneously improving the time taken from simulation to manufacture.

Simulation: Accuracy through correlation

CHALLENGE

The complex geometry of the annular design placed a heavy burden on simulation, creating another bottleneck in software performance and computing power.

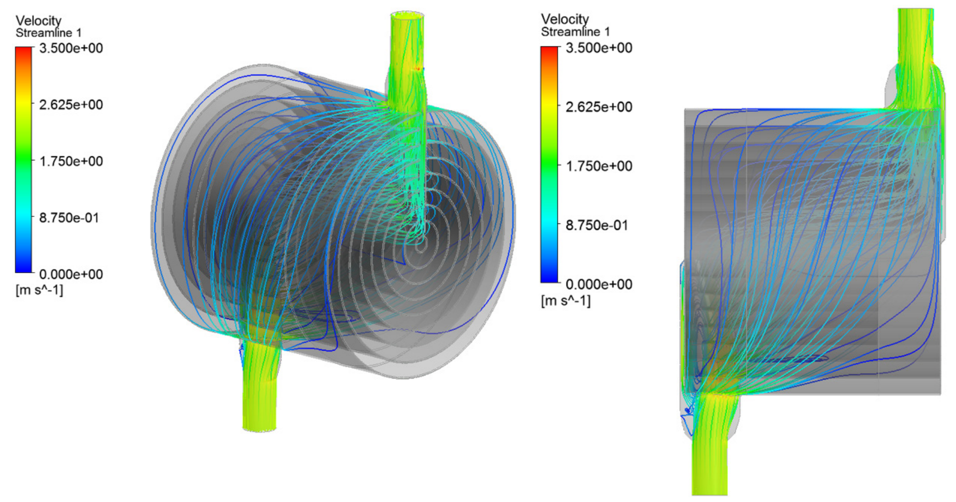
We also needed to accurately predict results given the surface roughness of the LBPF manufacturing method, specifically the pressure drop for a given geometry. Surface roughness generally increases the heat transfer performance through increased mixing and surface area. However, at small feature distances, it increases the pressure drop.

SOLUTION

We created sub-cores that our servers could handle. Those results were then applied to a scaled-up, but simplified model to get a sufficiently accurate overall performance estimate.

We achieved accuracy of predictions by building a large library of correlation data from the testing of our other heat exchangers, and then bringing that data back into the simulation to look for discrepancies between the results (i.e. simulation predicts A, so why are we getting B?). Our approach enabled us to simulate for optimisation of the basic core design and ensure close correlation with the real-world results.

FIGURE 1. Water flow within Annular WCAC HX Manifold



Manufacturing: Reliable, consistent parts for serial production

CHALLENGE

Integral to the success of the annular heat exchanger would be our ability to create reliable parameter sets, the configuration instructions for the 3D printer, that would achieve consistent thickness and a gas tight structure.

With LBPF, powder residue is inevitable and, given the complex geometry of the annular ring, we needed to find a means to fully remove it. If we couldn’t achieve this, the residue powder would impede the fluid flow.

SOLUTION

Using our build parameter optimisation developed over many years, we experimented with parameters, testing, failing and learning, until we succeeded in producing the extremely small, complex geometry reliably. The parameters are essential, any company attempting to manufacture an annular core would be unable to replicate our results without them. (Right, Conflux Technology’s liquid to liquid annular heat exchanger).

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Results: Compelling annular technology

RESULTS SUMMARY FOR ANNULAR WCAC

With our design we matched the heat transfer performance to the benchmark, which was the maximum achievable for the boundary conditions.

For the same heat transfer, we saw:

- **15% smaller core volume**
- **24% reduction in air-side pressure drop**
- **39% reduction in wet weight**
- **31% reduction in dry weight**

A 'Water Charged Air Cooler" (WCAC) is a heat exchanger that cools the high pressure air passing from a turbocharger to an engine.

We benchmarked our performance against the best commercially available microtube heat exchanger in the an extreme performance application - Formula One motorsport.

RESULTS EXPLAINED

Heat exchanger performance is measured by the transfer of heat between two channels of fluids. Whether cooling or heating the fluid, the outlet temperature quantifies the heat exchange. Pressure drop or hydraulic performance gauges the resistance of flow inside the unit. The goal is to meet as high a heat exchange and as low a pressure drop as possible for maximising performance.

In addition to both heat exchange and pressure drop, producing the smallest, lightest component is generally desirable in engineering, particularly so for motorsport and other demanding applications. The dry weight is the part without any fluids whereas the wet weight includes operating fluids.

Aligning the heat exchange performance allows a comparison of other attributes. For the same HEX, the Conflux WCAC operated with a dramatically lower pressure drop, physical size and dry/wet weight compared to the microtube WCAC.

See Figure 2, right.

These test results, the scalability of the annular design and the ability to tune our geometries to match most boundary conditions presented by our clients represent a new benchmark in heat exchange technology that surpasses previous engineering achievements.

Contact our team for further information about our annular technology heat exchangers.

FIGURE 2. Performance comparison between Conflux's WCAC & benchmark microtube WCAC

	Conflux WCAC	Difference %
HEX (KW)	124	-
Air dP (kPa)	18.9	-24%
Coolant dP (mbar)	56	-82%
Dry Weight (kg)	1.8	-31%
Wet Weight (kg)	2.0	-39%
Core Volume (L)	2.3	-15%

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