conflux TECHNOLOGY

Case Study: Our first patented design

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- 1/3 pressure drop
- 22% less weight
- Optimum form factor, 55mm smaller
- Monolithic structure - integrated functions, reduced part count & assembly costs, no joints or welds

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This is the story about the foundation on which Conflux Technology was built – our first patented design – a gamechanger at the time of its inception, and one from where we've now progressed in leaps and bounds. As evidence of the potential of additive manufacturing (AM) in heat exchangers, this first design enabled us to make our mark on the world-stage and further the progression of AM technology across many industries.

In 2014, our CEO and Founder, Michael Fuller, saw the possibilities of using metal additive manufacturing to create high-performance heat exchangers. Using a Formula One Test Map for the development process, Michael set about determining whether the design could make the grade within the most unforgiving environment – F1 motorsport – based on direct feedback from an international F1 team. A grant allowed us to leverage the skills of the CSIRO and their vastly experienced Fluids Engineering Group as part of the ongoing, iterative development of our heat exchanger design.

By 2017, this heat exchanger would be the ultimate reward for our collective efforts, leading to Conflux's seed funding, and the starting point from where all our product families have evolved. To call the realisation of this design as seminal to our business would be nothing short of an understatement.

Results Summary*

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- ✓ 1/3 pressure drop
- ✓ 22% less weight
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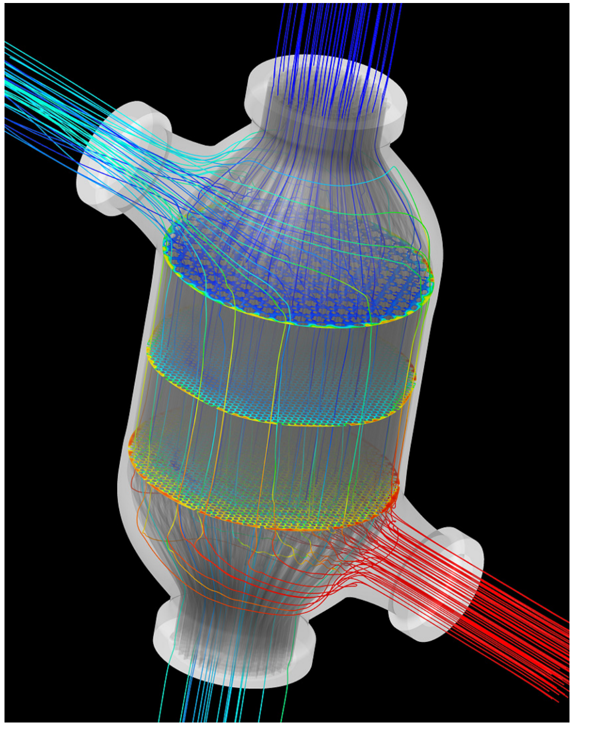
- ✓ Monolithic structure - integrated functions, reduced part count & assembly costs, no joints or welds

**When benchmarked against a traditionally manufactured motorsport heat exchanger*

To create a higher performing, lighter weight heat exchanger for Formula One

Heat exchange is a thermodynamic technology used across many industries, with its application in motorsport being one of the more complex due to the harsh performance environments and the demand for smaller, more efficient and lighter components. In the minds of F1 engineers, aerodynamics is king – similar to the requirements of aviation – so immense importance is placed on the ability to optimise the motor vehicle shape to maximum aerodynamic advantage using all the integrated parts and systems under the skin of the vehicle.

In developing our this heat exchanger, we were challenged with proving that AM – a form of manufacturing still relatively young in its maturity cycle – could adequately compete, and even beat, traditional manufacturing processes in creating lighter weight and higher performing heat exchangers. Similarly, the utilisation of 3D printing in heat exchanger development had been extremely limited up until this point, with many naysayers believing it could not be applied to heat exchangers at all.



Design

To prove viability of our heat exchanger for a Formula One application, we needed to design for a series of boundary conditions. This involved the development of cutting-edge geometries – high surface area density, combined with optimised fluid pathways and 3D surface features – that were rigorously tested to determine exactly what was possible, and what would provide the best performance standards.

Production

Given we were pushing the boundaries of AM capabilities, we faced many hurdles with the production. The walls of the heat exchanger needed to be very thin, with sub-optimal build angles and good material properties. This meant that we failed repeatedly but, ultimately, were able to learn from our failures because each attempt helped establish a new baseline for parameters in the machine and design.

Post-Processing

Powder removal was extremely complex, requiring multiple steps to successfully produce powder-free components. However, with this challenge, we accelerated our understanding of the behaviour of the powder in different environments. It also demonstrated how we could optimise powder removal in future parts, as well as design tweaks, so we could streamline the process.

With this design, we were charting new territory and, concurrently, creating a new industry baseline from our early learnings and R&D for others to follow. Not surprising, this was not an easy road to travel. Our team was constantly challenged with not just developing a new standard in heat exchangers but also with simulating, manufacturing and post-processing a pioneering form of technology.

Our first patented design – a heat exchanger that exceeded expectation

After a rapid proof-of-concept development program of six prototypes in six months, the final iteration of our heat exchanger was built and then patented in 2015. With it, we overcame all design, production and post-production challenges to unlock the potential of heat exchange technology using additive manufacturing – an achievement that many deemed impossible. We also demonstrated that having the freedom to package such a device in non-standard shapes was a huge benefit to integration, while being both smaller and lighter than previous heat exchangers.

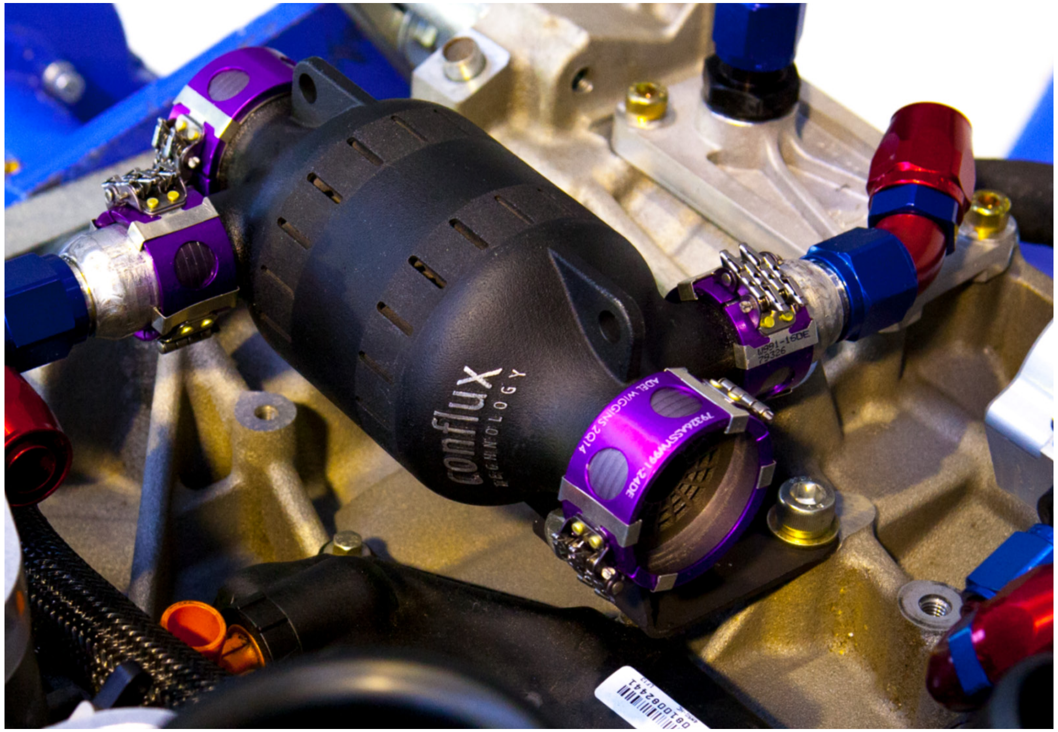
Heat transfer and pressure drop target across series of boundary conditions were confidently met. Cutting-edge geometries were accurately printed at intricate build angles. These lead to performance standards that went beyond what was previously attainable through conventional manufacturing.

We succeeded in aligning agile, iterative design with rapid prototyping and testing. The vertical integration of this 'design, simulation, build and test' model has since proven so effective that it has become the framework for our customer engagement on consecutive projects across the years.

SOLUTION

As well as representing the culmination of many years of R&D, our first patented design drew on several tools to reach its final form: Computational Fluid Dynamics (CFD) were initially utilised to enhance the heat exchanger design iterations with flow visualisations and then further utilised for performance predications; non-linear thermomechanical Finite Element Modelling (FEM) was employed to analyse displacements and stresses to maintain structural integrity; and AM-specific software tools from EOS assisted with data preparation, process optimisation and quality assurance.

However, our greatest tools by far were the technical talents and professionalism of our people. Through patience and unerring standards, the Conflux team came together to create an industry-redefining patent, which has spurred us to pitch for nothing less than perfection in moving forward.



New benchmarks that placed our design in pole position in 2016

A UKAS-certified laboratory for providing accredited calibration services and thermal fluid and component testing services in the UK, Young Calibrations, was tasked with comparing our first patented design to a conventionally made motorsport heat exchanger benchmark.

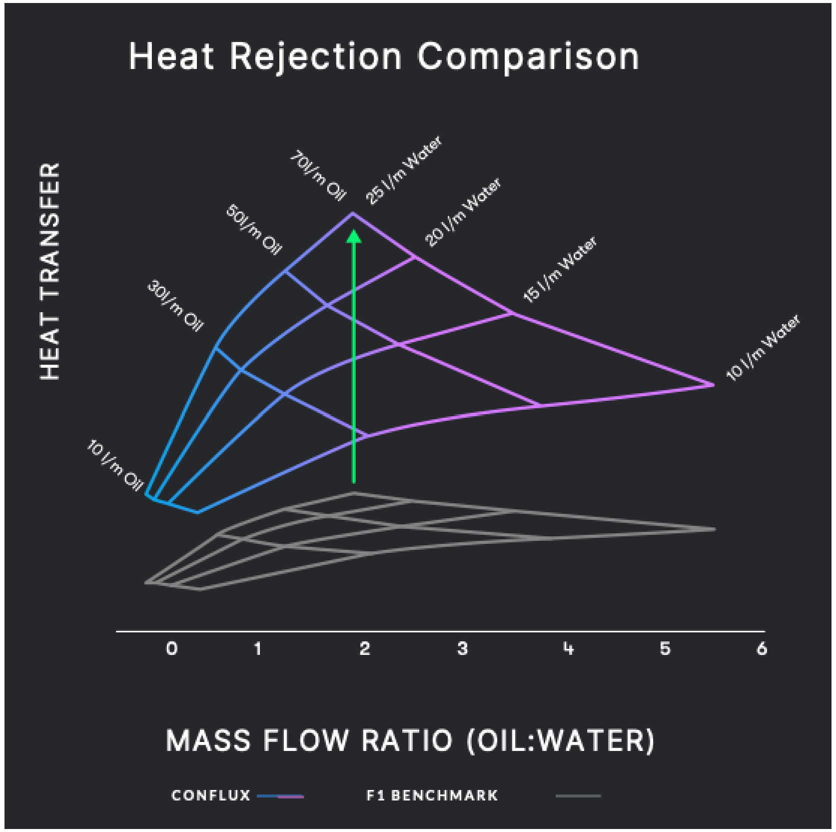
Key findings (see Figure 1) were:

- An increased surface area in any given volume, which tripled thermal heat rejection and simultaneously reduced the pressure-drop by two-thirds.
- A 55mm reduction in length on the heat exchanger benchmark, which effectively removed 22 percent of the benchmark's bodyweight.

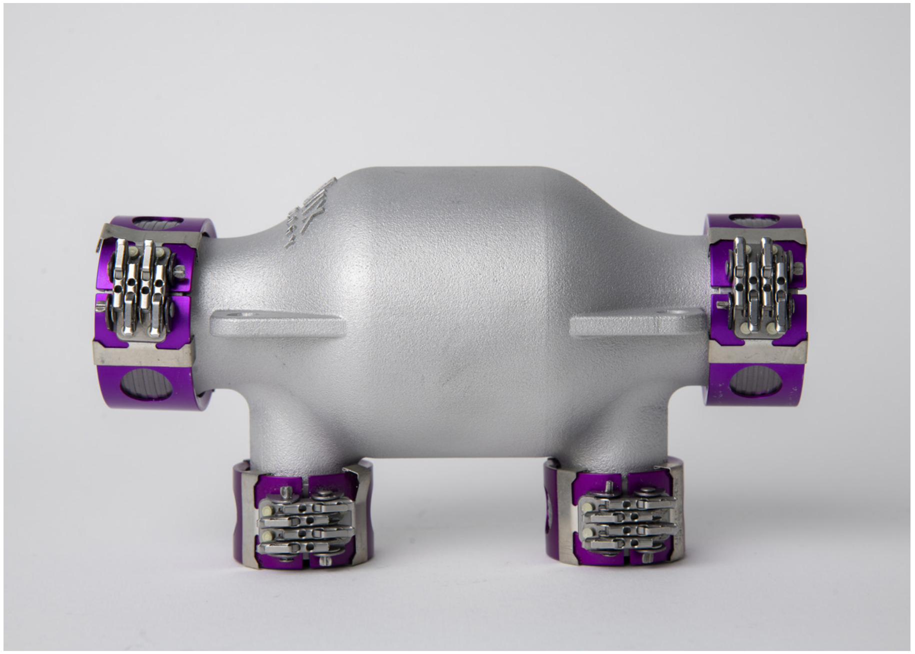
Along with these performance wins, the design flexibility of our first patented design was shown to facilitate optimal placement inside a motor vehicle, which enables the merging of components resulting in less parts overall. Additionally, the integration of sub-components into a single point means that the assembly of the heat exchanger takes significantly less time and the chance of failure points at joints and interfaces is decreased.

Conflux's heat exchanger design has gone a long way in proving that AM processes can be exploited to advance thermodynamic performance and usher in a new generation of heat exchangers. As with any groundbreaking moment, this design has proven to naysayers that what was questioned as possible is now a reality.

RESULTS



ABOVE: This table shows the heat rejection of Conflux Technology's first patented design compared with a traditionally manufactured F1 benchmark heat exchanger.



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