DHBW ENGINEERING Stuttgart

Facts

Challenge

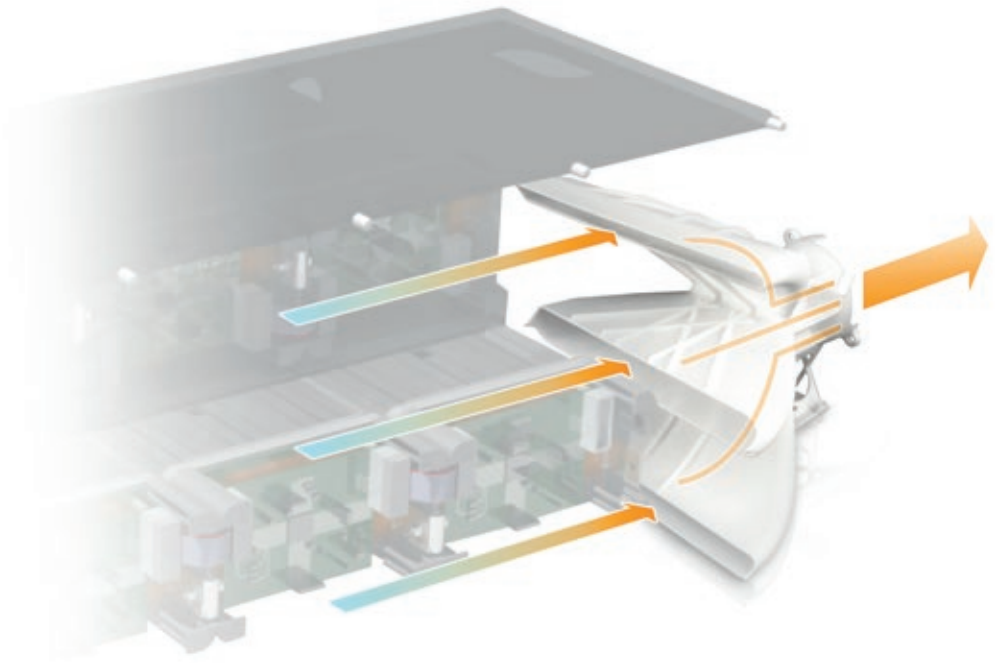
Build a high-performance cooling unit for a Formula Electric car that is integrated in the battery container of the vehicle.

Solution

Additive Manufacturing of a component to dissipate cooling air using the EOS P 396.

Results

- Lightweight: reduction of component weight by 80% to just 77 g
- Functional: design allows for fast servicing of safety-relevant parts
- High performance: well over twice the cooling performance compared to the previous year's car



The complex and lightweight component for dissipating heat reduced the top temperature within the container from 80 °C to just 50 °C. This translated to an increase in cooling performance of over 100% (courtesy of DHBW Engineering Stuttgart).

Serious Power: Cooling System for Formula Student Race Car Produced with Additive Manufacturing

e-Manufacturing Solutions

Student Racing Series Impresses with Electric Motor Innovation

Short profile
Baden-Württemberg Cooperative State University sponsors DHBW Engineering Stuttgart e. V., a club that enters a new racing team every year to participate in Formula Student Electric. Each season, different project teams construct a race car within the specifications set by the series.

Further Information
www.dhbw-engineering.de

Enzo Ferrari, Ferry Porsche, Ferruccio Lamborghini – all of them built sports cars themselves because they could not find one that fulfilled their desires. Every year, the dream of seeing your own race car at the starting line becomes a reality for the participants in the Formula Student race series. In line with current environmental concerns, the focus is on the electric engine. The eSleek14, belonging to the DHBW Engineering Stuttgart team, has two electric motors, each with 60 hp. The electricity that feeds this speed machine comes from batteries fixed laterally inside the vehicle. The construction of the air cooling system was supported by EOS in its role as Additive Manufacturing expert.

The Challenge

The drive unit of a vehicle with an electric motor is a complex construction. The actual drivetrain is simpler than with conventional combustion engines, but this is offset by the complications of integrating the energy storage units. In the eSleek14 these consist of lithium-polymer cells – 24 modules with a total capacity of 6.7 kWh. This powerhouse is contained in a battery housing made of fibreglass-reinforced plastic in a sandwich-type construction while an integrated battery management system (BMS) controls the charge and discharge of the individual cells.

Because of their cell chemistry, the lithium-ion batteries are flammable. The physical protection of the cell packs is as essential as the reliable ventilation of the system as a whole. This is because overheating can lead to damage and even a fire. In connection with the BMS, it is therefore vital to keep the build-up of heat under control. At the same time, optimised heat dissipation guarantees the best possible performance of the energy supply and ensures the distribution of power to the electric motor.

Fast and reliable: The race car with additively manufactured airflow in the battery housing achieved top rankings in the Formula Student events in Germany and Spain (courtesy of Formula Student Germany).

Another constant factor in the minds of the developers is the weight of each component. The battery unit must be as small and densely packed as possible in order to provide maximum power while taking up the least amount of space. Simultaneously, a defined range must be ensured – the proverbial squaring of the circle. This was the challenge faced by the eSleek14 designers. Their response also needed to meet the crash requirements of the formula series.

The Solution

Construction of the entire battery system was carried out in a way that ensured both mechanical and electrical protection, while optimising cooling. Three continuous channels guarantee air

supply and ventilation of the electricity storage unit by way of the in-flowing and out-flowing airstream. The cooling air enters from the front, is distributed along the cells via the three channels, is then reunited by a manifold, and finally is drawn back and up to be expelled by way of a radial fan – a technical masterpiece on the part of the constructors.

Such components are, however, not available off the shelf. Additive Manufacturing processes offer a particularly valuable option in this area. David Köhler, the man responsible for both the construction of the batteries for the 2013/2014 car and the cooling concept for the high-voltage device, confirms this: "We decided to have the cooling duct additively manufactured and, thanks to EOS' technology, we had complete freedom of design. With such small quantities, injection moulding didn't make sense, and we would have had to make changes to the construction design anyway." For the 2013/2014 season, as in previous years, EOS trained the team in how best to exploit the advantages of Additive Manufacturing.

In the development of the battery container it was possible to realize not only the cooling channels between the individual modules, but also a cooling duct that directed the air back outside in the most efficient way at the end of the container. In order to satisfy the strict specifications for component weight, the team chose the lightweight fine polyamide PA 2200 for the construction. This material is characterized by its high rigidity and good thermo conductivity – perfect characteristics for motor-sports applications.

Results

The air duct was produced using the EOS P 396, the laser beam melting the powdered material layer by layer to form the final component. Intensive component testing showed that the construction complied with all of the safety standards. The next step would be to successfully integrate the components into the vehicle. The weight also met the desired criteria: the cooling duct component weighs just 77 g. The importance of each gram is shown by the fact that the total weight of the eSleek14, at just 180 kg, converts to a power/weight ratio of just 1.5 kg/hp. In comparison, each unit of hp in the Porsche 911 GT2 road version converts to 3 kg in weight.

The team was able to increase cooling performance by well over 100%. In total, the temperature within the battery container fell from a high of 80 °C to just 50 °C. Distribution is also considerably more uniform. The results of the team at the Hockenheimring make it clear that nothing burns during the process of heat dissipation. Following a shock disqualification for excessive performance (!) in the acceleration test, the team showed its strengths in the endurance and efficiency competitions, with 4th place finishes in both categories. Despite the disqualification in the acceleration tests, the team was still able to achieve 7th place overall. A race in Barcelona ultimately proved that the car is not only fast but also reliable and efficient. "We kept pace with the best teams in the world. After Barcelona and Hockenheim we were in the top ten of the global rankings," summarizes Köhler with pride.

It is worth keeping an eye on the long-term results in the coming years. In its role as a training race series for the next generation of engineers the Formula Student has a value that is difficult to quantify. "Today we are laying the foundations for the innovations of tomorrow." This is something Nikolai Zaepernick, Head of Strategy and Business Development at EOS, is certain of. "For us this was a conscious choice. This type of application has great potential for use in electric road cars in the coming years."

"EOS' expert knowledge and technology have really helped us get our electric powered race car eSleek14 on the track and record great times. The advantages of Additive Manufacturing are very convincing: lightweight components, the fast realization of ideas, and all of this with extremely low part quantities. The available materials mean that safety is never compromised. Thanks to the instruction received from EOS we were able to get the maximum out of the process – and prove ourselves out on the track."

David Köhler, Assistant Head of Battery Development for the race team 2013/2014

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