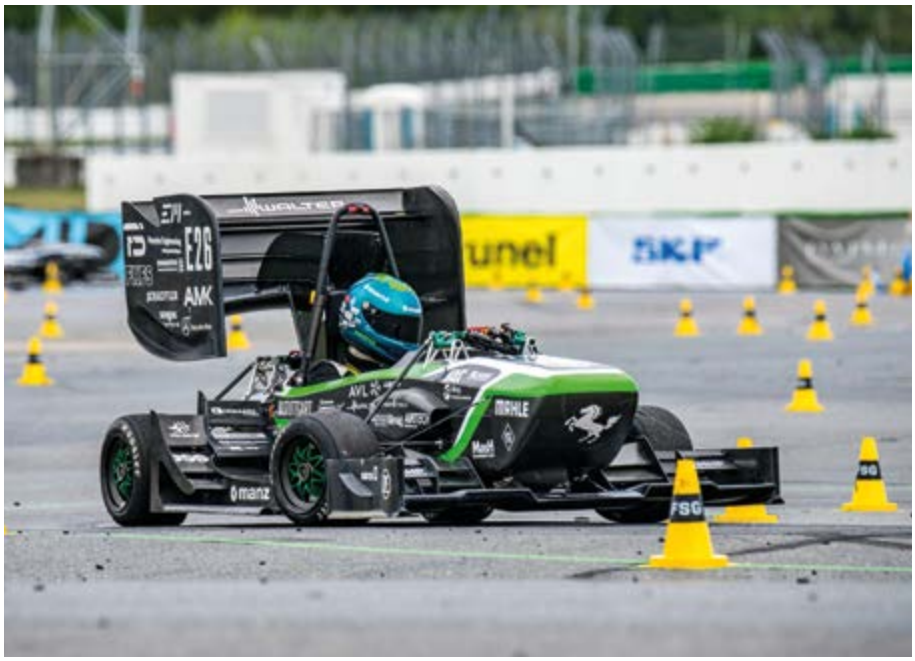
Customer Case Study
**Automotive**

# If You Race,
# You Need to Stay Cool

*Source: FSG - Jonas Haertl*




*Cool head thanks to cool battery: The GreenTeam Stuttgart's racing car*

**Challenge**

Design of a flow optimized, oil resistant and flameproof distribution unit for the cooling system of an electric racing car

**Solution**

Additive manufacturing from PA 2210 FR with an EOS P 396

**Results**

Freedom of design allows best possible circulation of the cooling medium

Component design saves weight and space

Flame retardant material meets fire protection requirements (UL94V-0)

Material withstands aggressive coolant

Cooling properties increase racing performance

# Formula Student Team Stuttgart Produces Oil Cooling **for Electric Racers by Additive Manufacturing**

Racers must keep a cool head - their cars should not overheat either. This applies equally to racing cars with combustion engines and electric motors. The difference: in fuel-fired racers the engine has to be tempered, in electric vehicles this must be considered in particular for the accumulator. The Formula Student team from Stuttgart has solved this task in the truest sense of the word with an additively manufactured oil cooling system and support from EOS.

## Challenge

A battery - as accumulators are called today - for an electric car has diva-like characteristics. It needs to be treated with caution. This applies not only to mechanical stress, but also to thermal stress: It doesn't like temperatures that are too high or too low. The reason for this is the behavior of the electron flow: If it is too cold, the electrons do not migrate fast enough for the maximum power output due to the higher internal resistance. If the temperature is too high, for example if the maximum power output is maintained for a longer period or if the climate is simply hot, there is a risk that membranes will be destroyed or that they will age more rapidly, even to the extent of the so-called thermal runaway.

In order to guarantee an optimum working range, appropriate systems are necessary; liquid-based solutions have the advantage that they can also heat the cells and thus maintain high performance - which is of course of central importance in racing. Oil cooling systems offer very good properties for the battery, but can only be realized with great effort using traditional construction methods: The filled quantity should be kept as low as possible in order to save weight. This also reduces space requirements, which plays a major role not only in tightly cut racing cars.

„In addition, the flow characteristics in the system are important for achieving a high volumetric flow rate," says Florian Fröhlich from the Stuttgart Formula Student GreenTeam. „Several aspects have to be considered in order to secure an optimum flow velocity, including the expedient design and the lowest possible surface resistance". The aim of the racing team was to ensure that a major part of the fluid constantly circulates in the area of the cell flags. Additionally, as oil is quite aggressive, the chosen material must feature a certain level of chemical resistance, while at the same time it must follow the lightweight character of the entire project. High fire resistance is obligatory in racing anyway.

## Solution

The young racing team set to work with this sporty technical wish list. Simulations on Computational Fluid Dynamics (CFD) resulted in the expedient design of the cooling system, which is made up of flux direction parts and inlet devices. The geometry was optimized in such a way, that a consistent flow is created through the outlets with their compact design and high surface quality. Due to the planned construction geometry and the incorporated hollow structures as well as, of course, the very small number of units, additive manufacturing was the best choice for the production process: The required flow properties would not have been reproducible with traditional methods.

The team used the flame-retardant PA 2210 FR as the material for 3D printing. The aggressive coolant can't harm it, so no particles can be dissolved out and clog the system. In addition, it is non-conductive and meets the necessary requirements for non-flammability. The actual manufacturing process took place on an EOS P 396, a system to build high-quality plastic parts. Before production, the team had carried out a few tests before the CAD data set was transmitted. The actual printing process was completed very quickly, as is usual with additive manufacturing.

„Production went absolutely smoothly and the material kept what it promised. We were able to convert our solution into a reliable and functioning real component as planned and within a very short time," explains Florian Fröhlich from GreenTeam. „The capability of developing a suitable structure around an ideal flow passage is simply perfect for a motor sportsman. And I already know that I will carry this experience into my professional life wherever I can. Simply because the results are so convincing."

### Short Profile

GreenTeam Uni Stuttgart e. V. was founded in 2009 and currently consists of approx. 65 students from a wide range of courses. The GreenTeam can look back on a successful past. Since 2010 the team has been continuously in the top 10 of the world ranking list of electric racing cars.

*For more information*
*www.greenteam-stuttgart.de*

„I see additive manufacturing as a revolutionary way of turning ideas into reality. For an engineer, it's like a dream come true: to think in terms of the optimal structure and not to have to make any compromises when it comes to shaping it... We will still need some time before we can optimally bring the incredible possibilities of 3D printing in all its facets to industry. Anyway, I'm proud to contribute to that process."

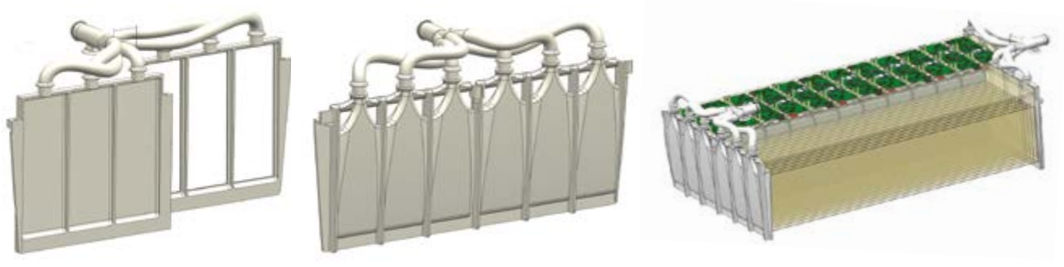
*Florian Fröhlich, GreenTeam Uni Stuttgart e. V.*

## Results

The fact that the outcome was as desired is also proven by figures. As mentioned above, the batteries used to power the racing car become very hot if a lot of power is accessed permanently. With the optimized cooling system, the GreenTeam can now use the possible 80 kW maximum power at any time during the whole race. In addition, the solution can preheat the battery pack to up to 45 degrees Celsius for the start of the race so that this power is available from the first lap. This gives the race team a significant performance advantage.

In addition, every gram of weight and every cubic centimeter of space in the car count for top performances on the circuit. And some of these have also been saved, because the overall system without pump, hoses and oil weighs only 225 grams; an additional fireproof impregnation is already included. On top, this was the only way to make ideal use of the limited space in the energy unit in a way to fill in the ideal quantity of the cooling medium oil - thus ensuring a permanent oil bath.

„We were able to install our cooling system smoothly. The flame-retardant material meets the fire protection requirements of UL94V-0. We are very satisfied with the results. The system works as we imagined it would. From our point of view, additive manufacturing is the only technology with which our component could be produced," summarizes Florian Fröhlich from GreenTeam. This also pays off for the race results: Since 2010, the team has been continuously in the top 10 of the world ranking list of electric cars. With the students' craving for innovation and convincing technologies, this will stay this way in the future.



*A complex battery system requires powerful heat dissipation - no big deal thanks to additive manufacturing (source: GreenTeam Uni Stuttgart)*

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