Firenze Race Team uses HyperWorks to Maximize the Component's Stiffness/Weight Ratio of its Formula Student Race Car

Overview

Formula SAE, also known as Formula Student, a competition between university student teams, is attracting university teams from all over the world to design, build, test, and promote a race car prototype and to compete against each other under real racing conditions. The competition is based on the design and realization of student-made "formula" type race cars of which performances are evaluated in an overall score within the following areas: design report, cost analysis, business plan presentation. Furthermore, acceleration, skid pad, autocross/sprint, and endurance & fuel economy of the car are put to the test in the actual race.

One of the competing teams is Firenze Race Team, the student team from the Department of Industrial Engineering of the Florence School of Engineering. To further improve their race car and to create better and lighter components, the team applies Altair's HyperWorks CAE suite, in particular HyperMesh for model creation, HyperView for post-processing tasks, and OptiStruct, the finite element solver and optimization tool of the suite, for structural optimizations and FEA tasks. To develop the new FR-15T (the car the team competed with in 2015) the Firenze Race Team has increased the use of HyperWorks to further improve the vehicle's performance, particularly regarding weight and stiffness.

Team

Firenze Race Team, established in 2000, is the oldest Italian Formula Student team. In 2002, the students began to design and build the first car, with which the team took part in its first competition in Leicester (UK). Until today, the team has successfully built six cars and won several prizes. For their 7th design, the FR-15T, the team involved in the development and manufacturing processes was larger than in previous years and comprised around 30 students.

For the design process, the team divided the car into eight system development areas, each of which a sub-team was responsible for. Also, each group of students was headed by one team leader, and two additional project leaders managed the design and manufacturing phases. The department involved in this project is the DIEF, the Department of Industrial Engineering of the Florence School of Engineering.

http://www.firenzerace.it/

High resolution rendering of the FR-15T

"We were very happy with the results we have obtained with Altair HyperWorks. The tool allowed us to improve the overall car performance, to enhance our development process and to reduce the weight of some of the components. In particular, we could improve the precision of the answer of the suspension system to the driver and the racetrack inputs, which additionally contributed to the over all performance of the car. Thanks to Altair's software we were very flexible in the definition process of the model e.g. direct selection of nodes for loads applications and direct management of the mesh creation process. Reaching our development targets would have been impossible without the Altair solutions."

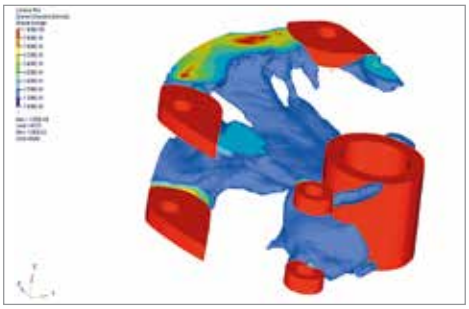
Matteo Giglioli: creation of the model, interpretation of the results and creation of the new rocker's geometry.
Patrick Gramazio, Cosimo Vannini: team members responsible for Altair's software suite.

Challenge

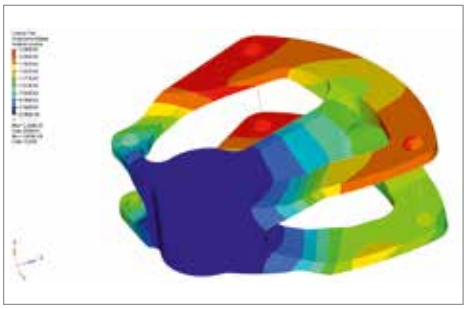
To determine the optimal solution and to meet the requirements regarding both, performance and low weight at the same time, is a big development challenge. To further improve the car's performance the team selected those vehicle components for a redesign that looked most promising in terms of reducing weight while increasing stiffness. One of the chosen components was a suspension rocker. Here the team strove not only for a weight reduction but also for an increased component stiffness to improve the suspension system's precision for a better handling performance. To this aim, the students not only had to consider different development goals at the same time but they also had to meet demanding deadlines. To reach all of these goals while getting optimal results the students had to use computer aided engineering tools such as the HyperWorks suite and a simulation driven design process. The tools and the method were not only applied to analyze the race car's prototype but to also "suggest" better solutions and design approaches.

Solution

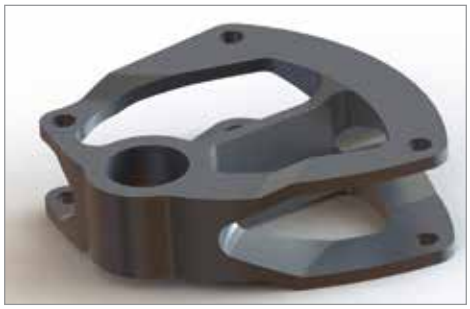
Firenze Race Team used Altair's HyperWorks suite, in particular the suite's meshing tool HyperMesh, to create the model, and they employed OptiStruct to solve and optimize the design in order to maximize the stiffness to weight ratio of the component. Thanks to computer aided engineering tools the team was able to streamline its development process, giving them extra time to further study important aspects in detail. In this particular case, the team optimized the geometry of a suspension rocker with OptiStruct and used the numerous visualization options from HyperView, the pre- and post-processor of the HyperWorks suite, to display the results obtained.
The first step of the optimization project was the import of the CAD geometry in HyperMesh, followed by the definition of the material. Then the students created design and non-design spaces, and applied additional input properties such as constraints and loads. After the creation of the mesh the team solved the model with OptiStruct, using its optimization functions. For this use case the team targeted the reduction of the volume while fixing the maximum deformation within the optimization process. After analyzing the result in HyperView, the team created a new geometry, which was then again evaluated in a static FE-analysis.



Optimization proposal from OptiStruct.



New optimized suspension rocker design.



CAD model of the optimized rooker design.

Results/Benefits

The optimization process resulted in a newly designed suspension rocker, which was weighing only 121 g. This represents a weight reduction of 37 % compared to the former design, weighing 192 g. While reducing the rocker's weight the team was also able to increase the component's stiffness leading to a reduced maximum deformation from 0.03 mm to 0.023 mm (deformation reduction of 23 %). In total, the stiffness to weight ratio was increased by about 105 %. In contrast to the former suspension rocker, which was an assembly consisting of 19 single parts, the new design is made of one piece without any bolts and nuts.
The team has overcome the development challenges of this project using Altair's HyperWorks suite, which allowed them to reduce the overall design time and to improve the final solution. The Altair software helped the team to design, test, and validate single components before a single prototype was built.
An additional benefit of using HyperWorks was that the team could increase their knowledge about Altair's HyperWorks suite, which will help them to face upcoming challenges even more prepared and which will be a big asset for their future carriers in engineering.
HyperWorks enabled the students to

- reduce component weight while increasing stiffness, hence to improve the performance of the car.
- speed up development time enabling more detailed evaluations in the given time.
- benefit from a great flexibility in the definition process of the model e.g. direct selection of nodes for loads applications and direct management of the mesh creation process.

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