Auburn University Applies HyperWorks to Optimize the Design of Composite Suspension Components and Monocoque for a SAE Formula Student Racecar

Overview

Formula SAE challenges students to conceive, design, build, and compete with small, formula-style racing cars. Teams spend 12 months designing, fabricating, and preparing their racecars for competition. The competition is based on a series of dynamic events that include skid pad, acceleration, autocross, and endurance/fuel economy. Team racecar design is also evaluated from static events that include team design review, business plan presentation, cost analysis, and static vehicle inspection.

Auburn University Formula SAE was Founded in 1996 and aims to produce efficient racecar designs that contend with top teams from around the world. To continually improve their racecar designs, the team applies the Altair HyperWorks computer-aided-engineering (CAE) suite of tools for increased stiffness and mass reduction. More specifically, Altair HyperMesh is applied for finite element model generation, HyperView for post-processing results, and OptiStruct, the finite element solver and optimization tool, for increased stiffness and mass reduction. The Auburn Team makes extensive use of composite materials for their racecar design. They applied HyperWorks to design and analyze composite parts such as the monocoque, aerodynamic ducting, suspension components, and front impact structure.

AUBURN UNIVERSITY

2016 competition season.

"HyperWorks allows our team to continue to grow in our knowledge of composites design and optimization, so that we can learn more, design a better car, and ultimately become better engineers"

Drew Campbell
Lead Monocoque Design Engineer, 2016 Auburn FSAE Team

Team History & Organization

The Auburn University SAE Racing Team has a 21-year history of dedication to designing and building formula-style racing cars. To date, the team has successfully built 20 cars and raced in SAE-sponsored events in the United States, Germany and Australia. Their current (AU-2016) and the future (AU-2017) car designs feature a carbon fiber monocoque structure, combustion powertrain and chassis control, and full aerodynamic surfacing.

For their latest design process, the team divided the car into three system development areas (powertrain, chassis, electronics), each of which was led by a lead engineer who managed a team of development engineers. The three sub-teams, in turn, were led by a team captain. All team members worked closely with a faculty advisor and marketing team, led by a marketing director. The Auburn Team is affiliated with the College of Engineering Department of Mechanical Engineering. For more information, please visit Auburn Formula SAE's team page at: www.auracing.org

Challenge

A significant challenge for Formula SAE teams is to determine an optimal design solution while meeting constraints related to mass and SAE racecar specifications. To optimize the car performance, the team focused on selected components that were most promising in terms of mass reduction with equal or increased stiffness. One of the chosen areas of focus was the monocoque chassis. For the monocoque design, the chassis team wanted to achieve mass reduction while increasing monocoque suspension stiffness to improve racecar handling. To meet this design objective, student team members not only had to consider concurrent development design goals, but they also had to meet demanding build deadlines.

Using Altair HyperWorks, Auburn Formula SAE was able to reduce the weight of the monocoque by 22% and the chassis by 37%, while increasing overall stiffness.

The Solution

The Auburn Formula SAE Team applied the HyperWorks suite of computational tools to implement their simulation-driven design process. HyperMesh was applied to generate finite element models and OptiStruct was employed to solve and optimize the design and to optimize the stiffness-to-mass ratio of components. HyperView was applied to view and comprehend the optimized structure.

More specifically, for the monocoque suspension mass optimization, CAD geometry was initially imported into HyperMesh and a meshed model was created. After assigning composite material properties to the primary monocoque structure and aluminum properties to the bonded end cap, design and non-design regions of the model were specified. Loads were also input, and the maximum monocoque displacement was constrained to a maximum allowed value. A three-step OptiStruct optimization process for composite structures was then applied to minimize the monocoque volume. After analyzing the optimized results in HyperView, the team created a manufacturable geometry, which was subsequently evaluated using linear finite element analysis to ensure that all design requirements were met.
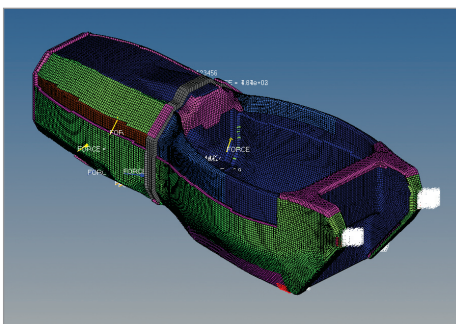
Finite Element Model for the Composite Monocoque
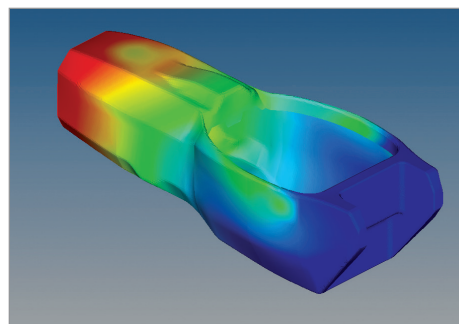
Displacement Results for the Composite Monocoque
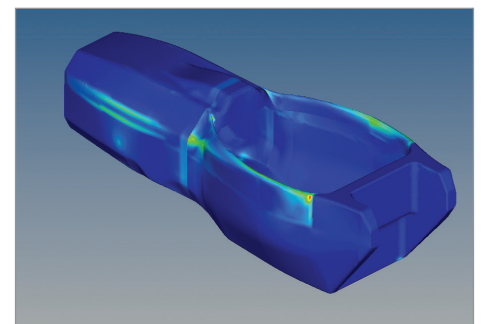
Von Mises Stress Results for the Composite Monocoque

Results/Benefits

The optimization procedure applied to the carbon fiber/aluminum suspension monocoque resulted in a mass reduction of 50% from the baseline of their previous all aluminum design. The final design had a stiffness equal to that of the original design. The total chassis weight of the racecar was 51 lbs., which exceeded the team mass savings goal by a considerable margin. The chassis torsional stiffness of 4,000ft-lb/deg also met the car design objective.

The Auburn Team overcame many development challenges during the course of the car development. The application of HyperWorks played a significant role in allowing them to meet the challenges. The simulation-driven design approach allowed the team to design, test, and validate single components before an initial car prototype was built. It also enabled a significant reduction in the overall design time. An additional benefit of applying HyperWorks was that team members could increase their knowledge of the HyperWorks suite, therefore giving them tools to take with them into their future professional engineering careers and preparing them to face real-world design challenges. To learn more about Altair University sponsorship and how our software can help your team succeed, visit altairuniversity.com/sponsorship.

In summary, HyperWorks enabled the Auburn FSAE Team to:

• Reduce component mass-to-stiffness ratio, thereby improving the car performance.
• Speed up development time, which allowed for more detailed design evaluation.
• Grow in knowledge of composite material design and optimization, thereby becoming more experienced engineers.