Student Team H_2politO of Politecnico of Torino Applied HyperWorks to Reduce Vehicle Weight and Fuel Consumption on Shell Eco Marathon Europe Competition

Overview

Student teams from around the world participate in the Shell Eco-marathon (SEM), a unique low energy consumption competition for student teams. Within the competition the teams strive to design, build and drive the most energy-efficient car. In three annual events in Asia, Americas, and Europe, student teams compete on the track to see who goes furthest on the least amount of fuel. The competition evaluates different aspects of the car, the most important of which is of course the energy consumption: the less energy the car needs, the better it will rank. Further categories in which the car is rated include technical innovation, project exposition, and design. The team H_2politO, a group of students of the Politecnico di Torino, participated in the "Prototype" category with a hydrogen fuel cell vehicle, and in the "Urban Concept" category with a hybrid vehicle that has both, an internal combustion engine (fed with bioethanol) and an electric engine at the Shell Eco-marathon Europe.

To further improve their vehicles, the team H_2politO targeted reduced frictions and masses to minimize fuel consumption. H_2politO therefore applied Altair's HyperWorks Suite with the aim to optimize the wheel rims by determining the ideal mass distribution with a given maximal stress level - while also taking into account manufacturing constraints. Since the wheel rims are rotating components, that is, rotating masses, they are ideally suited to improve the car's energy consumption, handling, and dynamic behavior. The optimization of the wheel rims resulted in a weight reduction of 18% of the component compared to the last year's design. The optimized wheel rims were then built and tested on track, and demonstrated a good behavior during all the race steps.

Team H_2politO

The Prototype IDRA - hydrogen fuel cell category- at the Shell Eco-marathon.

Team H_2politO

The team H_2politO is a group of students from the Politecnico di Torino. The students' backgrounds and profiles are very diverse, with students coming from various engineering disciplines. Each of them contributes his or her special expertise and together they compose the team that is responsible for the car's design and construction. The engineering disciplines involved in the project range from automotive and mechanical to electronics, aerospace, energy, mathematics, computer science, mechatronics, management, cinema & media and industrial design. The team is based in the Mechanical and Aerospace Engineering Department (DIMEAS) of Turin's Politecnico, and led by Prof. Massimiliana Carello.

The team's mission is to shape a new generation of engineers: leaders in their fields, who represent the educational excellence in regard to each of their competencies. The results from the team's passion and hard work are two low-energy consumption vehicles that could become benchmarks for their categories: IDRA – a hydrogen powered prototype; and XAM – an ethanol powered parallel hybrid urban concept. The vehicle for the SEM 2015 IDRA has been a complete restyling on the basis of an existing carbon fiber monocoque of a prototype built in 2009.

"Our main goal is of course to participate in the Shell Eco-marathon with a great car and possibly win the competition. We are striving to share the Shell Eco-marathon values by combining a sustainable development with a vehicle that uses the least possible amount of energy, and HyperWorks did a great deal to support this effort. We believe that the competition is a perfect way to achieve excellence. It gives us the possibility to work hard in order to challenge the competitors and to produce a more advanced technology vehicle that could become benchmark for its category."

Prof. Massimiliana Carello, Politecnico di Torino.

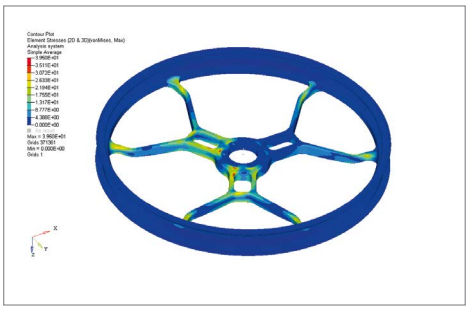
Challenge

The targets for the 2015 vehicles were to reduce frictions and masses in order to minimize fuel consumption. Starting from there, one of the most critical issues was the wheel rim design. Lighter rims lead to less rotating masses, reducing energy consumption and improving the dynamic behavior of the vehicle. To this end, the geometry of this specific component had to be optimized: the ideal structure and mass distribution had to be determined, while also taking manufacturing constraints into account. For these development tasks the H_2politO team had to apply sophisticated computer-aided engineering (CAE) tools which would support a simulation driven design process and enable early decision making by proposing possible design directions for further improvements of the vehicles.

Solution

H_2politO team applied Altair's HyperWorks suite to design and optimize the rims. At the same time the tools also enabled them to consider any technical constraints such as tire design specifications and constraints that might apply to the chosen manufacturing technology for the rims, which were in this case turning and milling. The material the team wanted to use was, due to its lightness and other beneficial material characteristics, an aluminum alloy.

To optimize the rim structure, the students used OptiStruct, Altair's FE solver and optimization tool, which is included in HyperWorks. The first step was the definition of the component's design space, which in this use case was the full rim cylinder (divided in different zones) including a zone for hub linkage and the tire profile. Then occurring loads and other boundary conditions were applied. The following optimization study simulated the real test for the rims, applying the forces to the most critical zone near the hub. The resulting mass distribution provided the basis for a detailed CAD model of the rim. In a last step, the team used static analyses to validate the results.



Stress contour plot of the wheel rim

CAD model built in solidThinking Evolve

Wheel rim in the milling manufacturing step.

Results/Benefits

Thanks to the HyperWorks suite and the included optimization tool OptiStruct, the team could reach a weight reduction of around 18%, compared to last year's wheel rim design. Reaching this weight reduction was a very important step for the team, since this weight saving reduced rotating mass, and resulted not only in less weight, but also improved the car's handling and dynamic behavior. The wheel rims were tested on the track during the Shell Eco-marathon Europe 2015, from May 21-24 in Rotterdam. The components demonstrated a good behavior during all steps of the race. With their vehicle IDRA the team reached the 6th place, with a consumption of 328.8 kg/m^3.

One of the most important benefits of this development approach was the ability to also include the constraints of the desired manufacturing technologies. HyperWorks' topology optimization solution OptiStruct offered great opportunities for the team: they were able to increase the performance of the vehicle by delivering an ideal mass distribution and by enabling a CAE-driven design process, which resulted in a more streamlined development process. The main benefits of using Altair's HyperWorks suite to develop the team's vehicles are:

- a significant mass reduction with the same mechanical performance,
- FEA and CAD integration to reach design targets,
- ability to cover different production technology early on in the development process.

More information about the Team H_2politO, sponsors, and partners: www.polito.it/h2polito.