HyperWorks Meets the Challenge of Energy-saving Racing Vehicles

Introduction
Shell Eco-marathon is a worldwide educational program that is held in America, Europe and Asia. Its aim is to educate the future generations to take a different view of energy as well as how we use it. The Prototype group competes on future concept car models, i.e., the streamlined cars that could help maximize the fuel efficiency by innovative approaches, such as reducing resistance. All racing vehicles are single seated and equipped with three or four wheels, and the steer area is either open or closed. The City Concept Car group is more focused on energy-efficient cars that are suitable for regular roads. In terms of usability, such racing vehicles are more similar to ordinary ones.

Prototypes from Tongji University ZEAL Eco-Power team have been present at Honda Energy-Saving Sports Tournament both in Japan and in China. In 1981, Honda founder Mr. Soichiro Honda founded the Honda Energy-Saving Sports Tournament in Japan. Over 500 racing teams take part in the competition every year. This event came to China in 2007, being named Honda China Energy-Saving Sports Tournament, and has been successfully held for 8 years so far. The racing vehicles are equipped with 125 cc fuel-efficient 4 stroke engines exclusively provided by Honda, with parts like frames and bodies being developed and produced by the racing teams themselves. The final winners and losers are determined by fuel consumption.

The ZEAL Eco-Power team has participated in this competition for years, always with good results. This would not have been possible without using HyperWorks software for design simulation and vehicle weight reduction before the physical production. Despite the differences between Prototypes and City Concept Cars in quite a few technical aspects, remarkable effect has been exhibited in both of these car models.

The Challenge
For competition in energy-saving sports, the total weight of the racing vehicles should be reduced as much as possible without compromising the rigidity, because this brings less fuel consumption. To that end, the ZEAL team decided to use OptiStruct, a finite-element based structural optimization tool in the HyperWorks suite, to analyze and optimize their designs and has been attempted to apply FEA to composite materials for recent seasons. The optimization result turned out to be significant with both car models.
ZEAL Eco-Power has achieved excellent results in a variety of energy saving themed contests with OptiStruct optimized prototypes. The racing vehicle in the left picture won the first prize in 2015 Honda Japan Energy-Saving Sports Tournament for the New Challenge group.

With the powerful capabilities of HyperWorks in composite material analysis, the Zeal team was able to make major breakthroughs in vehicle structure. The picture on the right shows the first racing vehicle with an all-bearing body designed and produced by the ZEAL team.

The ZEAL team designs and produces a Prototype each year, and a City Concept Car every three years. The target total weight of a Prototype is about 50kg while that of a larger-sized City Concept Car is 75kg. This means that weight reduction has to be taken into account at the very beginning of the design stage.

Since few could be done to reduce the weight of the vehicle shell as restricted by aerodynamics and the engine was to be specified by the contest committee, the students put their focus on the frame and transmission parts. However, the limited budget and tight schedule forced them to find a reliable design method aside from numerous physical tests. In comparison with optimizing old ones, design of new vehicle frame and parts from scratch is often performed in absence of support by analysis, which would be nothing else but taking a blind risk. By using OptiStruct the students managed to design vehicle parts light yet rigid enough before physical production.

**The Solution**

OptiStruct enabled the ZEAL team to make new breakthroughs in vehicle structure for both Prototypes and City Concept Cars. With the use of simulation and optimization tools in recent years, the team not only has achieved weight reduction on vehicle parts, but also debuted a prototype with an all-bearing body in 2014. This breakthrough technology enables further weight reduction through replacement of aluminum frames with carbon fiber composite ones, while greatly simplifying the manufacturing procedure of the vehicle since the frame and shell can be formed all at once with the help of the fabricator.

For the ZEAL team, lightweight design is involved throughout the entire design process. It is no longer the simple sum of individual jobs of certain team members, but a major task that requires coordinated efforts from multiple technical groups. In the past few seasons, the transmission group and the vehicle group worked together to optimize the structure of the chain drive sprocket and reduce its weight to a great extent. From early modeling in Catia, through to meshing with HyperMesh, structure optimization with OptiStruct and the final processing by HyperView and OSSmooth, a light-weighted and easy-to-fabricate part was designed. Through this fast design process, the students could quickly obtain optimally weighted parts that meet the functional and rigidity requirement. Currently, the members from the two groups identify front axle steering as their next target for optimization design. They wish to achieve a stronger and lighter front axle through optimization of both materials and the structure.

The sprocket weight was reduced with the topology optimization capability of OptiStruct

An all-bearing body was achieved through composite material analysis

The application of HyperWorks in prototype design was not limited to weight reduction. The ZEAL team also used HyperMesh for pre-processing of other analysis, thanks to the strong meshing capability and sound output compatibility. Importing shell meshes of higher quality into the meshed flow field grids can help increase the accuracy of fluid analysis.

In 2015, the team made its first try on designing the frame of the City Concept Car using OptiStruct. With the created finite element model, the team generated the preliminary frame layout based on the results of topology optimization under stress constraint and by taking into account the welding process of aluminum frame and how the internal parts would be installed. After the frame digitax was improved, the slab bridge unit was used again to test the load capacity to make sure that the stress response and displacement of the frame met the expectation.
Case Study

The ZEAL Eco-Power team for the first time used OptiStruct for weight reduction design for the frame of City Concept Cars.

The team's next goal is to design City Concept Cars with an all-bearing body, which also requires analysis to be performed using HyperWorks. With the support from Altair Engineering, the students are looking for additional potential of weight reduction by conducting explicit analysis with RADIOSS, welding spot modeling and simulation with connector module, dynamic analysis with OptiStruct, etc.

The Result

The ZEAL Eco-Power team has always been dedicated to reducing the weight of Prototypes and City Concept Cars and improving their design and production processes with sound simulation results. For Prototypes, the design process with HyperWorks simulation has enabled them to break new grounds based on what they already had and will continue to assist them in designing racing vehicles with less weight and higher energy efficiency. While for City Concept Cars, the light-weight design of the frame contributes to significant reduction of the vehicle weight, which in turn allows for great savings in fuel consumption.

The application of HyperWorks has obviously contributed a great deal to ZEAL Eco-Power's success. With HyperWorks and its structure optimization tool OptiStruct, the ZEAL Eco-Power team was able to achieve:

- 10% weight reduction in Prototypes (the sprocket alone 70% lighter) and 12% in City Concept Cars without changing the original structure and body rigidity
- accelerated development process and savings in time and cost
- less material use and physical tests
- multiple first prizes in Energy Saving Sports competitions

The team won the first and third prizes in Honda China Energy Saving Sports Tournament of 2014. In 2015, the team won the championship of Honda Japan Energy-Saving Sports Tournament, which was its first championship since its participation in this event. In March 2016, the newly designed City Concept Car will compete in Shell Eco-marathon Asia in Philippines for even better results.