ANSYS®
CASE STUDY

Leading Motorsport Team Races to Get Car Design Right the First Time

PENSKE

EXECUTIVE SUMMARY

Challenge:

To design a racecar that meets the stringent criteria and tight deadlines of the Indy Racing League

Solution:

Use ANSYS® to analyze changes during the design phase of product development

Benefits:

Able to make early, intelligent decisions about design, including materials and manufacturing

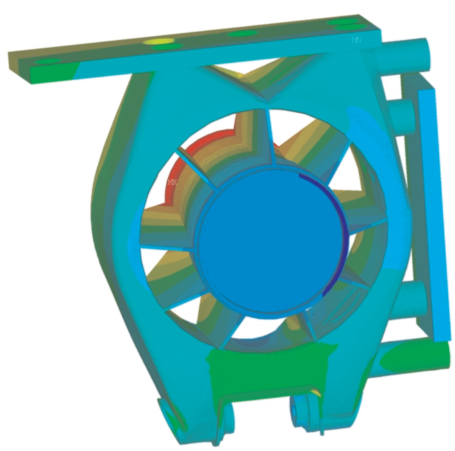
Able to stiffen an upright by 25 percent without increasing weight

Introduction

Next to Mario Andretti, there is, perhaps, no more recognizable name in American motorsports than Roger Penske - racing and winning in the U.S. since 1958.

After 45 years of racing, Team Penske embarked on a new and exciting challenge. With 115 Indy car wins, including a record 12 Indy 500 victories, Team Penske entered the Indy Racing League (IRL) on a full time basis. This meant competing with different equipment on 15 different tracks.

Moving to the IRL presented a challenge not just to the team on the track, but also to Penske s design team in Poole, Dorset, the company s traditional home base. Technical Director Nigel Beresford leads the eight-strong design team, which combines a healthy mix of recent graduates and experienced racecar designers. They now have to operate under a new set of stringent rules that govern the construction on cars competing in the IRL.



ANSYS model of an upright

Challenge

"The IRL is a technology restricted formula," says design engineer Chris Kirk. We have to work within very body-design tight criteria and are limited in what we can change. Competing cars have to use chassis from one of three manufacturers, for example, and have to use the same gearbox, so major alterations are impossible.

An added complication is the time factor. There is only a five month window between seasons, which runs from early March to September, and the car must arrive at the first race tested and ready to win. Prior to the first season in 2001, for example, we built a new wind tunnel model of the chassis in just six weeks.

Even during the five-month off-season we are very restricted in the design changes we can make. Cars have to be ready by January for testing, so we cannot analyze every single part of the car each season, said Kirk. We have no time for back-up plans or mistakes. We have to get it right the first time to give the team optimum performance.

Solution

The design team uses Pro/ENGINEER as their primary design program running on HP C3700 hardware with ANSYS finite element analysis (FEA) for testing design changes. ANSYS significantly shortens time-to-market by allowing engineers to utilize basic analysis capabilities during the design phase of product or part development. The program provides designers with access to the same underlying analysis techniques that will be deployed later for detailed product certification, enabling them to make early, intelligent decisions about design, materials, and manufacturing.

"Over a week, we built an ANSYS model using solid and shell elements, and the testing highlighted an area of the upright that was over flexing. We were able to redesign the upright, which when it was retested was 25 percent stiffer for the same weight."

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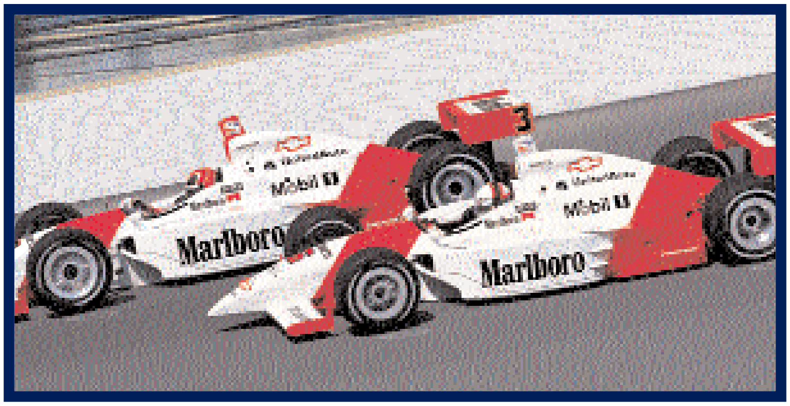
Using ANSYS, the racecar is broken down into many small simple blocks known as elements. The behavior of each individual element is described with a relatively simple set of equations. Just as the set of elements would be joined together to build the final product, the equations describing the behaviors of the individual elements are joined into an extremely large set of simultaneous equations that describe the end product's behavior. The software then is used to solve this large set of simultaneous equations. From this solution, FEA software can extract the behavior of the individual elements. This method is the only proven way to deal with complex boundaries and provides efficient solutions to "real world" physics-based problems.

FEA provides a way to deal with engineering problems that are more complex than can be dealt with analytically using partial differential equations. In the absence of FEA, engineers must rely on hand calculations. For complex designs, such as a racecar, the simplifying assumptions required to make any calculations can lead to over- built or heavy end products. In addition, hand calculations require the building of prototypes and field tests. These field tests may involve expensive strain gauging to evaluate strength and deformation.

ANSYS uses precise equations, which can help to minimize the weight of a design. Since the expected loads have already been assigned to the design on a computer, there is a reduction in the number of prototypes that need to be built. Field tests are then used to establish the loading on structures, which is then used to make future design improvements via FEA.

Benefits

"Because of IRL rules, we are limited to changes on the suspension and the aerodynamic area in front of the rear wheels. A number of minor changes can each give tiny benefits, which together can make all the difference to the car's performance," said Kirk. "The cars race for several hours and often cross the finish line within hundredths of a second of each other so tiny speed advantages can make big differences to race results. For example, we designed a new upright, which has to be both light and stiff and can significantly affect performance.



With 12 Indianapolis 500 wins, Penske Racing is the most successful Indy car racing team in history.

courtesy of Penske Racing

"Over a week, we built an ANSYS model using solid and shell elements, and the testing highlighted an area of the upright that was over flexing. We were able to redesign the upright (a suspension component), which when it was retested was 25 percent stiffer for the same weight. This dramatically improves the feedback that the driver gets from the steering wheel and provides the information to help him drive more effectively."

Penske also uses ANSYS for composite analysis. A considerable problem from a composite FEA point of view is the increased amount of data involved, due to the ply lay-ups, versus normal homogeneous material models. ANSYS provides the user with a number of easy-to-use tools for firstly checking the validity of the composite material modeling used, and secondly helping the user to evaluate the results through the composite lay-up that are of importance. Nonlinear material behavior and material failure models can also be used to evaluate problems in the composite design.

Kirk continues, "The way we lay-up composites can be a powerful way of effecting performance and we find that ANSYS handles them all in a very user friendly way and, using IGES, we can transfer the data between ANSYS and Pro/ENGINEER faultlessly."

Once the ANSYS model is constructed, we can alter the ply layups quickly to find the optimum. It is not commonly known that there are many different types of carbon fibers, different weaves in the cloth, and resin systems to bind them. The engineers can quantify the effects and recommend the best layup for a given part. For aerodynamic pieces, the team can find the loads, which the part will experience from wind tunnel testing. They also must abide by the rules, which prevent excessively flexible parts being used to gain an advantage.

Under IRL rules, constructors use the same chassis for three years, therefore, at the end of the 2005 season; Penske will have to start all over again with a new wind tunnel model and testing program. Still, if they maintain Roger Penske's philosophy that "Effort Equals Results" then their first IRL Championship can't be far away.

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