Changing The Game

Optimization Technology is finding solutions to challenges in design, manufacturing, distribution, and finance

Red Cedar Technology | By JoAnne L. Catlin

Red Cedar Technology is an MSC Software Community Partner that develops optimization software to help engineers design innovative products and find solutions to challenges in design, manufacturing, distribution & finance. The company's software solutions integrate with all MSC Software products including MSC Nastran™, Marc®, Adams™ and Adams/Car.

Many software companies offer optimization methods that have been "added on" to math models to resolve design, engineering, distribution and financial problems. These add-ons often require expertise in optimization, because the user must first have enough knowledge to select an appropriate optimization approach (i.e., gradient based, genetic algorithm, particle swarm), and then to enter the tuning parameters that will correctly direct the search method's exploration of the design space. There is another challenge here, as well: as the optimization study progresses, the problem may require a different search method to resolve a set of conditions that arise. In this situation, the analysis typically either fails or yields erroneous results.

For over a decade, Red Cedar Technology has focused on helping companies solve problems through the application of optimization techniques. By overcoming the technological barriers presented by other optimization tools, Red Cedar Technology has developed game-changing optimization software that is not only powerful, but requires no optimization expertise to use and allows human interaction with the optimization process.

HEEDS MDO multidisciplinary design optimization software is at the center of this technology. With the revolutionary search strategies available only in HEEDS MDO, engineers can uncover new design concepts that improve products and significantly reduce development costs. HEEDS MDO benefits users in two key ways: design space exploration (including parameter optimization, DOE, and robustness and reliability) and process automation.

Fast, Robust Optimization with SHERPA

HEEDS MDO's proprietary optimization method, SHERPA, is the most efficient and robust available, shortening design time significantly – often from weeks to days. Shorter design time translates into reduced product development costs. SHERPA is a hybrid, adaptive strategy that performs global and local searches simultaneously. It also learns as it progresses. At the same time, SHERPA provides a more thorough search for design possibilities (feasible and infeasible designs) with the potential to yield truly innovative designs that satisfy multiple, often conflicting, criteria. No tuning parameters are required for SHERPA. The user simply defines the objective of the study, and the parameters and constraints, and then tells HEEDS MDO how many evaluations to conduct.

Automated Integration with MSC Software products

HEEDS MDO process automation allows the user to set up, and then automatically repeat, a multidisciplinary study integrating HEEDS MDO with MSC Software products. The process automation component requires little effort. The desired process is manually set up once, and then it is automated by HEEDS MDO.

Industry Example: Pratt & Miller Uses HEEDS MDO with Adams/Car

Pratt & Miller Engineering has evolved from a small business focused on designing and building race cars into an international engineering powerhouse. Today Pratt & Miller is recognized around the world as a formidable force in both motorsports and high-level engineering and small volume manufacturing. After evaluating multiple optimization tools, Pratt & Miller concluded that HEEDS MDO, and its proprietary SHERPA algorithm, is the only optimization technology that can solve their highly constrained models. According to Pratt and Miller's Jesper Slattengren, "The SHERPA algorithm is currently superior to anything else that exists on the commercial market." For many of their optimization studies, they integrate HEEDS MDO with Adams and Adams/Car.

Pratt & Miller's typical optimization studies are set up as nearly over-constrained problems. They usually need to minimize or maximize only one or two objectives, but there can be up to 50 constraints that need to be satisfied. Examples of common constraints include gradient, overshoot and damping of roll displacement, yaw rate, lateral accelerations, maximum allowed steering wheel torque, limited lateral acceleration and various ride criteria.

Prior to using HEEDS MDO, Pratt and Miller would plan for 4 to 12 man-weeks to find an acceptable solution for their typical optimization problem. This was in addition to the time required to generate the baseline model using a combination of engineering intelligence and DOE methods. Using HEEDS MDO and parallel processing, this time has been reduced to one to two weeks.

Integration of HEEDS MDO with Adams and Adams/Car

For Pratt & Miller, a typical problem requires their engineers to meet all of the explicit requirements for a military vehicle (HMMWV) while maintaining good ride and handling performance.

In this example situation, the problem statement is to find the optimal spring and damper settings for a 2-axle vehicle under two different loading conditions: curb vehicle weight (12,000 lbs) and gross vehicle weight (16, 000 lbs). It is difficult to find springs and dampers that perform well in this context. The best solution must provide optimal ride characteristics, meet all military-mandated requirements for ride and handling, and meet or exceed a number of secondary ride and mobility requirements. With four people working for over three weeks manually using Adams, a solution was not found.

Study Setup

The HMMWV's springs, bump stops and dampers were parameterized in Adams. Adams/Car was used to set up several different runs:

- Drop-off test (at both loading conditions: curb vehicle weight and gross vehicle weight)
- Ramp steer (at constant velocity at gross vehicle weight)
- Constant radius cornering (at gross vehicle weight)
- Half round obstacle crossing (at curb vehicle weight)
- RMS road (at curb vehicle weight)

Using zero crossing detection and peak identification in Adams, Pratt & Miller calculated actual damped frequencies and damping based on logarithmic decrement.

Adams and HEEDS MDO were integrated through the use of a .cmd file and the Adams command language. In this study, 200 evaluations were run. Only 61 of them satisfied all constraints, and the optimum was found after 123 runs.

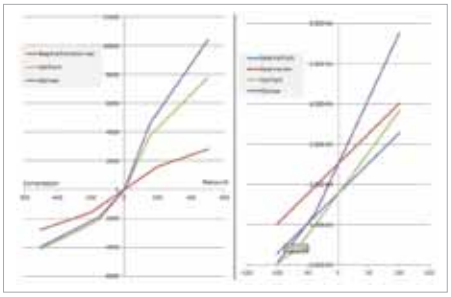
Results

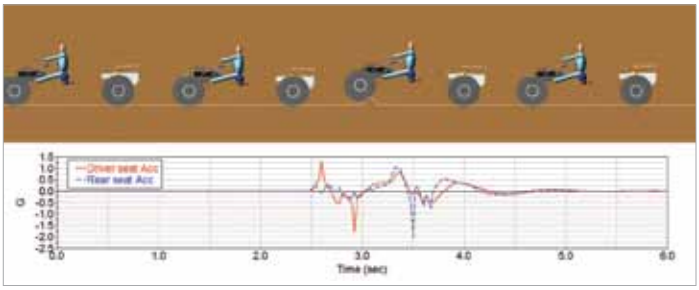
The heave and pitch frequency needed to be around 1Hz, with pitch greater than heave. This was satisfied by the optimized design. The lateral acceleration needed to be maximized, and it went from 0.60 to almost 0.70G, which is a significant change for such a heavy vehicle. The roll gradient needed to be below 14.00 degrees per G, and the optimized design had a roll gradient of 13.20 degrees per G. The yaw rate overshoot needed to be below 8.00 and started at 16.00. The optimized design had a yaw rate overshoot of 2.00. Finally, the roll overshoot needed to be below 8.00. It started at 20.00 and ended up at 5.40. The tables below summarize the results.

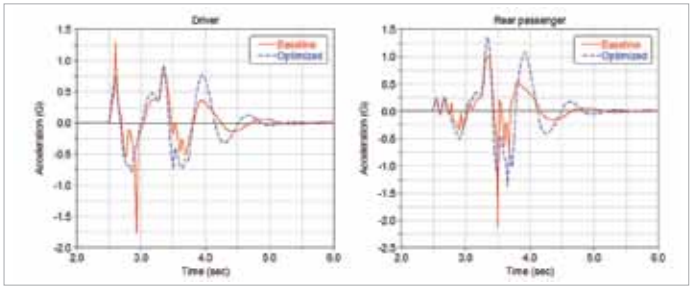
> "HEEDS MDO and Adams make a powerful combination & are easily integrated"

Pratt & Miller has discovered that HEEDS MDO works well with over-constrained or nearly over-constrained systems. Additionally, HEEDS MDO and Adams make a powerful combination and are easily integrated.

For more information about Red Cedar Technology's optimization software, please visit: www.redcedartech.com. ◆







Passing a half-round obstacle at specified speed (baseline). Vertical acceleration at all occupant locations < 2.5G.