Gathering all the Puzzle Pieces

Multi-objective optimization software works in an open environment and automates the entire design

ESTECO, MSC Technology Partner | By Maja Engel

Simulating reality has become an essential part of any design and engineering process with the aim of avoiding expensive and time-consuming physical prototype testing. After identifying variables and objectives, the main difficulty lies in finding the best compromise among optimum designs in order to produce the ideal solution, taking into account different constraints and parameters. Unfortunately, many of such input parameters are completely opposite in their nature, which raises a multi-objective dilemma: how to consider the full range of every single (sometimes conflicting), parameter without prejudicing one or the other? Is it possible to manually identify the best combination of variables and obtain top results without neglecting any detail?

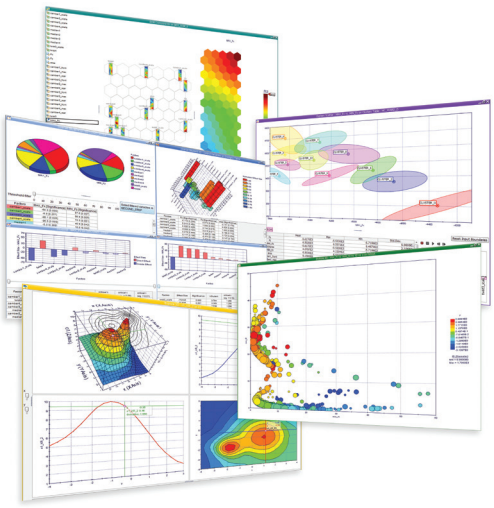
Nowadays these issues are faced by several companies who are forced to invest in engineering consultancy and infrastructure, often with very time consuming efforts. With this in mind ESTECO has developed a software aimed at making product engineers' job easier. modeFRONTIER is a multidisciplinary and multi-objective design optimization platform, capable of integrating design and simulation tools into a single IT environment. ModeFRONTIER automatically restricts the number of best possible solutions on the basis of the input data and places them on the tradeoff curve known as the Pareto Frontier. The Pareto Frontier focuses on efficiency and offers a spectrum of optimal combinations of the objective function. A great advantage of modeFRONTIER is that it can be coupled with any software (CAD, CAE or general application tools), whether commercial or in-house, and it enables the simultaneous use of a number of such software packages even on different machines. It also includes a wide range of post-processing features allowing the user to perform very detailed statistical analysis and data visualization, and facilitate his/her decision. In certain cases it is not possible to predict all factors that might influence the performance of a design; however, modeFRONTIER allows the user to carry out a robust design analysis and to identify the most stable solution even when applying minor perturbations of input variables. modeFRONTIER can be applied to basically any industrial sector: from aerospace, automotive and biomedical to the design of general consumer goods.

modeFRONTIER is directly coupled with MSC Software's Adams Multibody Dynamics Simulation software, largely used in the automotive industry. The combination of MSC's Adams Multibody Dynamics Simulation and modeFRONTIER allows the design engineer to exploit industry innovation while maintaining top performances of vehicles. Let's take as an example Ducati Corse, Ferrari, AUDI and FIAT, all of whom reached invaluable results by integrating modeFRONTIER and Adams.

Ducati Corse was faced with the challenge of designing a better performing racing motorcycle. Their starting point was to obtain experimental data by means of an on-board GPS-INS data acquisition system in order to measure parameters such as torque on the handlebar, steering angle and suspensions deflection. Those data were used to subject the vehicle body to a simulation in Adams and the final objectives were to improve steer torque and rear damper speed. By coupling modeFRONTIER with Adams, Ducati managed to reach the best combination of not less than 19 control parameters (such as bike suspension characteristics, inertial properties, geometry and so forth) and obtain reduced saddle "kicking" and a significant improvement as regards both objectives throughout the entire racetrack. [Ref. MSC EMEA 2004].

Ferrari's ultimate goal was to create a new, quicker and more stable sports car. They chose to focus on several crucial points, such as the reduction of design development and model testing, gaining knowledge regarding vehicle dynamics before building the first prototype and assessing the robustness of the selected model. Ferrari used the Adams/Car software to develop a full vehicle model and integrated it with modeFRONTIER to automate time-consuming tasks: devising the process workflow, modifying input parameters, defining constraints and producing a synthesis of results. In regard to this particular model, the objectives were to minimize understeer and maximize traction considering certain constraints, such as oversteer, maximum steering wheel angle and maximum distance from road centerline. modeFRONTIER managed to bring forth an optimized neutral solution, to which robust design criteria were applied taking into account small variations of input parameters that might occur "on the road". Therefore, the new model was not only faster and more stable, but also most importantly – entirely feasible.

Audi focused its main attention on speed, more precisely on the minimization of lap time of their race car. Since aerodynamics plays an important role in this respect, it is safer and more cost-effective to "try-out" different parameter combinations in the virtual environment. The input variables



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were the coordinates of the fundamental points of the diffuser and the inclination and height of the rear wing of the vehicle and each design was evaluated in 12 different positions to measure the actual aerodynamic forces. modeFRONTIER tackled a real-life multidisciplinary optimization problem by successfully integrating third party and Adams software packages. It managed to achieve an improvement of the lap time of 2,36 seconds, increase vehicle speed in different parts of the track and reduce fuel consumption, while reliably solving each process integration issue and design optimization problem.

FIAT used the customized version of Adams/Car, called MB-SHARC, to run simulations and monitor key parameters representing handling and ride-comfort performances of a small commercial passenger car (FIAT 500), taking into account also the robustness of the solution. The optimization, performed with modeFRONTIER, concerned the suspension mount characteristics and involved an initial DOE allowing users to select important input variables and representative objectives and constraints. The use of modeFRONTIER saved time and reduced the efforts spent normally on daily continuous modifications of the models and multiple analyses. It also helped acquire a complete understanding between all inputs variables and vehicle performances and to obtain the Pareto frontier containing an optimum set of solutions from different conflicting aspects [Ref. NAFEMS Benchmark Magazine, April 2009 edition].

modeFRONTIER is and remains one of the best-performing existing multi-objective optimization software packages. It allows the user to work in an open environment and automates the entire design and simulation process (even if a number of other software packages are involved) in a single workflow, generating a number of solutions that the user must choose from on the basis of subjective criteria. Coupled with MSC’s Adams software, modeFRONTIER opens a series of new possibilities: engineers don’t have to hassle with combining input variables one by one trying to find what is best, performing real and costly simulations and working separately on each software package to account for all the different aspects in designing a vehicle. modeFRONTIER can gather all the pieces of the puzzle, interlock them and fit them together leaving the decision maker facing only the final design choice. ◆