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Design challenges of off-highway hybrids

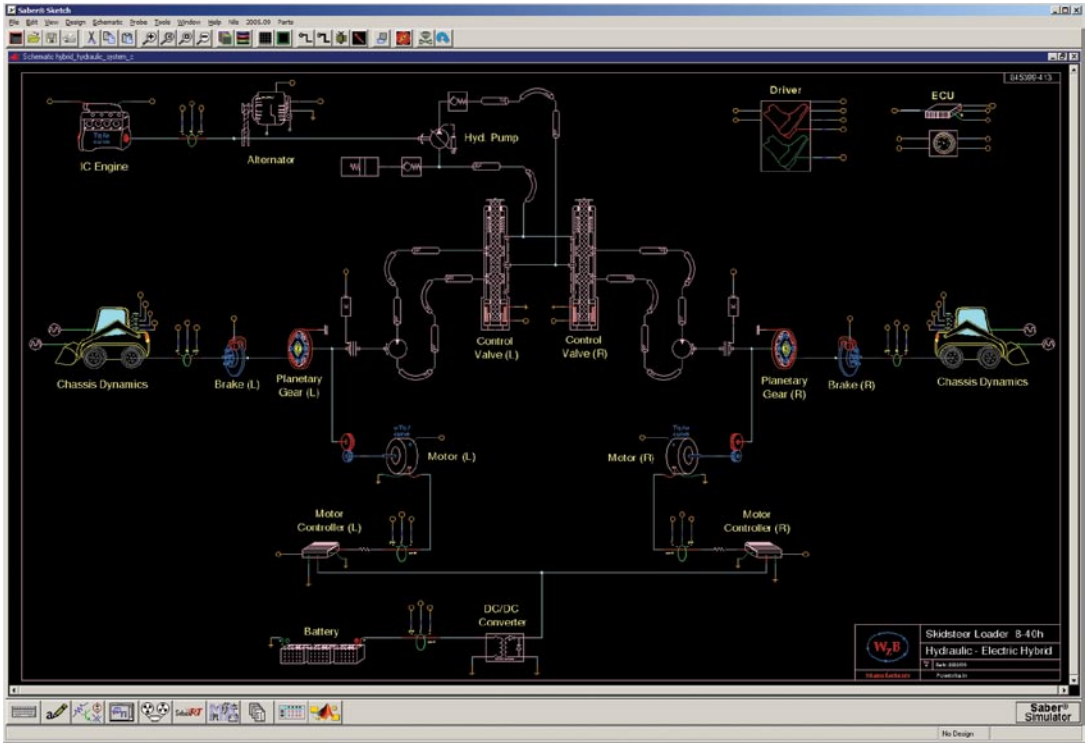
Hybrid vehicles in general are very complex systems requiring unprecedented integration between control and the electrical, mechanical, and hydraulic systems. Add to this the rigors of off-highway environments, and design teams are challenged to produce hybrid vehicles that are cost effective to build yet reliable to operate.

To meet these challenges, design teams such as those at **Synopsys** are increasingly turning to the use of Robust Design practices for off-highway hybrid vehicle design. Robust Design compensates for significant sources of variation that can affect a design, including manufacturing tolerances, environmental conditions such as temperature, and product wear.

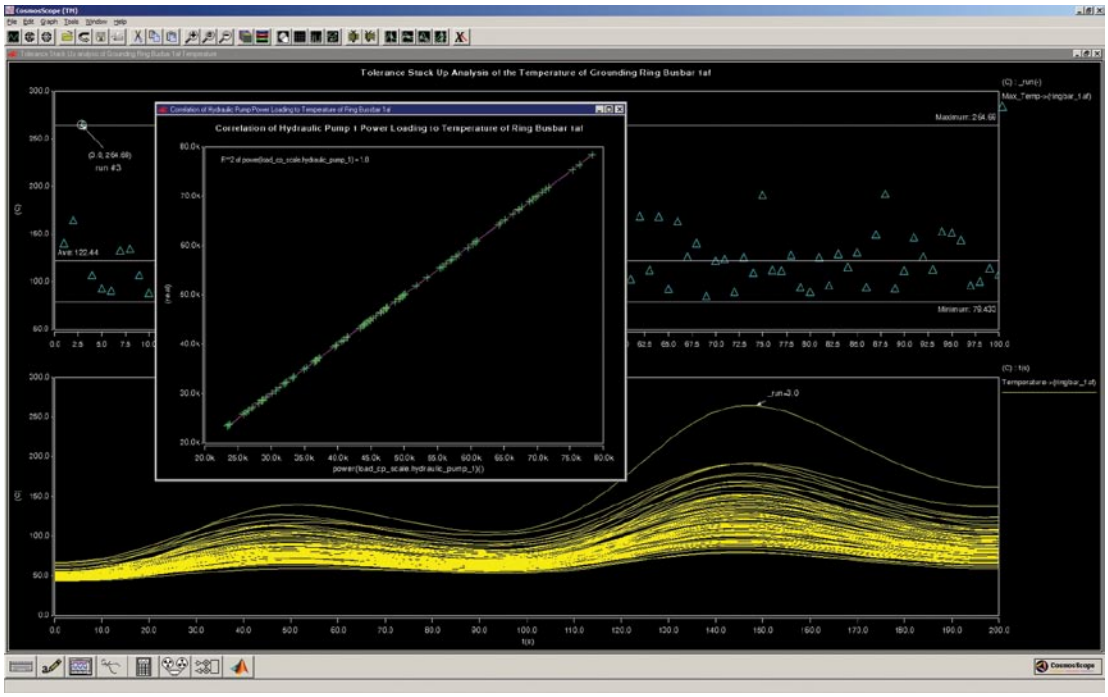
The goals of a Robust Design process are to produce the simplest and least expensive product that still meets customer satisfaction goals throughout the product's life under all specified use conditions, which can be extreme for off-highway vehicles. Accounting for all conditions that affect vehicle performance can be a formidable design challenge.

A Robust Design methodology provides a systematic framework that design teams can use to meet reliability objectives. A typical Robust Design process includes the following steps:

- Creation of a nominal case design that operates according to base specifications, but does not include behavior due to variability or operational conditions
- Identification of all relevant sources of variability with respect to a particular design
- Structured design testing (typically using simulation)
- Analysis of the effects of variability upon measures of performance
- Modification and tuning of the design to meet overall design goals.



An example of virtual hydraulic-electric off-highway vehicle design; as new systems such as hybrid vehicles are introduced into the off-highway industry, designers have seen a sharp increase in the need to run more simulations for virtual prototyping.



Robust Design methods are normally referred to as Taguchi methods or Six Sigma methods, which involve iterative analyses such as Monte Carlo or Pareto analysis. The objective of Robust Design is to compensate for all significant sources of variation that can affect a design.

Design teams can implement these steps using the traditional techniques of design, prototype, and test. Building numerous prototypes for an effective Robust Design flow, however, can be both cost and time prohibitive. These critical restrictions create the opportunity to use virtual prototyping. Virtual prototyping involves using software to create the system design, and employs behavioral simulation and analysis to replace physical prototyping and measurement. Once a virtual prototype has been created, a series of simulations are run to analyze and verify system performance.

Because of the need to analyze system performance across a broad range of manufacturing tolerances and environmental conditions, an effective design process built on Robust Design principles is simulation intensive, particularly true during the statistical analysis stage, where thousands of simulation runs are frequently required to get meaningful results. Often the only way to handle this amount of simulation is through the use of grid computing, where statistical simulation runs are distributed among CPUs on a compute grid.

The combination of virtual prototyping and Robust Design techniques help insure increased reliability, at a reduced cost, of off-highway hybrid vehicles. High-performance design tools support key analyses and simulation techniques used at all stages of the Robust Design process for the design, simulation, and verification of multi-domain systems—essential aspects of reliable off-highway hybrid vehicle development.

This article was written for ***SAE Off-Highway Engineering*** by **Nils Johnson**, Saber Corporate Applications Engineer, Synopsys.