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A Robust Optimization of Chassis Durability/Comfort Compromise Using Chebyshev Polynomial Chaos Expansion Method

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Abstract : The chassis system is composed of complex elements that take up all the loads from the tire-ground contact area and thus it plays an important role in numerous specifications such as durability, comfort, crash, etc. During the development of new vehicle projects in Renault, durability validation is always the main focus while deployment of comfort comes later in the project. Therefore, sometimes design choices have to be reconsidered because of the natural incompatibility between these two specifications. Besides, robustness is also an important point of concern as it is related to manufacturing costs as well as the performance after the ageing of components like shock absorbers. In this paper an approach is proposed aiming to realize a multi-objective optimization between chassis endurance and comfort while taking the random factors into consideration. The adaptive-sparse polynomial chaos expansion method (PCE) with Chebyshev polynomial series has been applied to predict responses' uncertainty intervals of a system according to its uncertain-but-bounded parameters. The approach can be divided into three steps. First an initial design of experiments is realized to build the response surfaces which represent statistically a black-box system. Secondly within several iterations an optimum set is proposed and validated which will form a Pareto front. At the same time the robustness of each response, served as additional objectives, is calculated from the pre-defined parameter intervals and the response surfaces obtained in the first step. Finally an inverse strategy is carried out to determine the parameters' tolerance combination with a maximally acceptable degradation of the responses in terms of manufacturing costs. A quarter car model has been tested as an example by applying the road excitations from the actual road measurements for both endurance and comfort calculations. One indicator based on the Basquin's law is defined to compare the global chassis durability of different parameter settings. Another indicator related to comfort is obtained from the vertical acceleration of the sprung mass. An optimum set with best robustness has been finally obtained and the reference tests prove a good robustness prediction of Chebyshev PCE method. This example demonstrates the effectiveness and reliability of the approach, in particular its ability to save computational costs for a complex system.

Keywords : chassis durability, Chebyshev polynomials, multi-objective optimization, polynomial chaos expansion, ride comfort, robust design
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