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TOWARDS OPTIMAL DESIGN OF ENGINEERING SYSTEMS

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The paper presents a review on methods, algorithms and tools available for optimal design of engineering systems. The focus primarily is put on methods and algorithms for global sensitivity analysis (GSA) and solution of Pareto optimization problems (POP) for multidimensional nonlinear mechanical systems. The computer code SAMO, developed at Mechanical Systems, Division of Dynamics, Chalmers University of Technology, is presented as an efficient toolbox for optimal design of engineering systems with different applications. The toolbox SAMO includes two modules: SAMO-GSA and SAMO-POP.

The module SAMO-GSA is developed based on the multiplicative version of the dimensional reduction method. In the SAMO-GSA an efficient approximation is employed to simplify the computation of variance-based sensitivity indices associated with a general function of n-random variables. The GSA results are presented as a mapping of the design parameters of the engineering system in question and total sensitivity indices of the objective functions. These results might be used as an input to the SAMO-POP for multi-objective optimization.

The module SAMO-POP works based on genetic algorithm. The genetic algorithm setting includes lower and upper bounds for variation of the design parameters, population size, number of generations, elite count, and Pareto fraction settings. The results of SAMO-POP are presented in terms of Pareto fronts and corresponding Pareto sets for further analysis and decision making by the user.

The efficiency of the proposed algorithms and developed toolbox is illustrated, first on scholar applications (thermally induced stress intensity factor and quarter car vehicle model), and second by the GSA and solutions of several multi-objective optimization problems for nonlinear multidimensional mechanical systems which represent high-speed train bogie suspension [2, 3], hand-held impact machines [4], drivetrain systems [1], others.

The computational model of bogie suspension of a high-speed train developed for optimal design of stiffness-damping suspension components to enhance vehicle safety and comfort as well as to minimize wear is presented in figure 1, (left). The results of GSA of bogie suspension is depicted in figure 1, (right), as mapping between the sensitivity indices of comfort, safety and wear and

fourteen design parameters of the system in question. Details of the results obtained can be find in [2, 3].

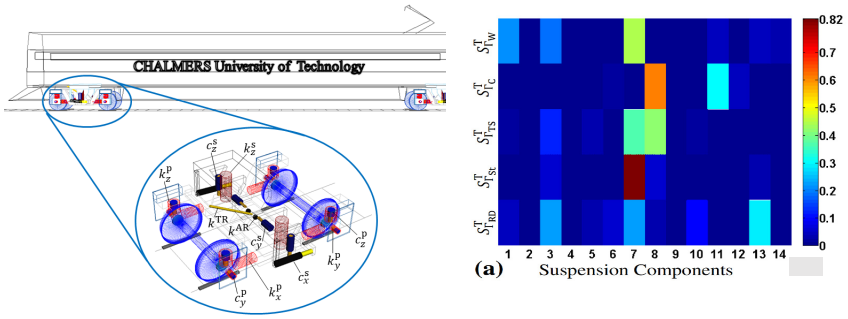

Fig. 1 Model of bogie suspension (left) and results of the GSA (right), [1, 2].

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ДО ОПТИМАЛЬНОГО ПРОЕКТУВАННЯ ІНЖЕНЕРНИХ СИСТЕМ

Представлено огляд методів та алгоритмів для оптимального проектування інженерних систем. Основна увага приділяється методам і алгоритмам глобального аналізу чутливості і розв'язанню задач Парето оптимізації для багатовимірних нелінійних механічних систем. Комп'ютерний код SAMO, розроблений у відділі Механічних систем, Chalmers University of Technology, представлений як ефективний інструментарій для оптимального проектування інженерних систем різноманітного призначення.