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A Sensitivity-based Coordination Method for Optimization of Product Families

Jun Zou[1], Wei-Xing Yao[2], Jun-Feng Zheng[3]

[1] Nanjing University of Aeronautics and Astronautics, Nanjing, China, sc.zoujun@gmail.com
[2] Nanjing University of Aeronautics and Astronautics, Nanjing, China, wxyao@nuaa.edu.cn
[3] Nanjing University of Aeronautics and Astronautics, Nanjing, China, zjfbest@nuaa.edu.cn

Abstract

Due to the highly competitive global marketplace, the contradiction between product variety and development and production costs is prominent. Under this backdrop, the product family design has received considerable attention from both industry and academia in recent years. This article discusses the bi-level decomposition approach for the optimization of product families with predefined platforms, and the challenge lies in providing an optimal compromise between the competing needs of all family members.

To improve the efficiency of the system coordinator and reduce the number of iterations needed for convergence, in this paper a new sensitivity-based coordination method (SCM) is proposed. The family problem is decomposed into several subproblems and one system coordinator. Each subproblem is responsible for specifying the variables for one family member, and the task of the system coordinator is to coordinate the different design of shared variables obtained from subproblem optimizations. The key idea in the SCM approach is that the system coordinator not only provides consistent shared variables, but also makes tradeoff between all the products by using of sensitivity information. The coordinated shared variables are determined by minimizing performance deviation with respect to the optimal solution of subproblems and constraints violation. The first order Taylor series approximation is introduced to evaluate the values of performance deviation and constraints violation.

As many other decomposition-based methods, the family design problem is decomposed naturally by individual product. This decomposition by product variant provides many benefits, such as simplifying the analysis integration, reducing problem complexity, and enabling concurrent design of all product variants. A sequence of nondecreasing penalty parameters guide the optimization process to convergence.

The numerical performance of the proposed method is investigated, and the results suggest that the new approach is robust and leads to a substantial reduction in computational effort compared with analytical target cascading (ATC) method. In addition, both the formulations of SCM and numerical test suggest that the SCM is also suitable to the MDO problems that the subsystems are only linked through a number of shared variables. Then the proposed methodology is successfully applied to the structural optimization problem of wing structures for an unmanned aircraft family, which is more complicated and related to practical implementation issues.