

Article

Multidiscipline Design Optimization for Large-Scale Complex Nonlinear Dynamic System Based on Weak Coupling Interfaces

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Abstract: For high-tech manufacturing industries, developing large-scale complex nonlinear dynamic systems must be taken as one of the basic works, formulating problems to be solved, steering system design in a more preferable direction, and making correct strategic decisions. By using effective tools of big data mining, Dynamic Design Methodology was proposed to establish a technical platform for Multidiscipline Design Optimization such as High-Speed Rolling Stock, including three key technologies: analysis graph of full-vehicle stability properties and variation patterns, improved transaction strategy of flexible body to MRS interface, seamless collaboration with weldline fatigue damage assessments through correct Modal Stress Recovery. By applying the above methodology, a self-adaptive improved solution was formulated with optimal parameter configuration, which is one of the more favorable options for higher-speed bogies. While within a velocity (140–200) km/h at $\lambda_c < 0.10$, car body instability's influence on ride comfort can be easily improved by using a semi-active vibration reduction technique between inter-vehicles through outer windshields. Comprehensive evaluations show that only under rational conditions of wheel-rail matching, i.e., $0.10 \geq \lambda_{cr} > \lambda_{crmin}$ and $\lambda_{crmax} = (0.03–0.06)$, can this low-cost solution achieve the three goals of low track concavity, optimal route planning, and investment benefit maximization. So, rail vehicle experts are necessary to collaborate and innovate intensively with passenger transportation and steel rail ones. Specifically, by adopting rail grinding treatment, occurrence probability is controlled at 85% and 5% for track concavity of (0.03–0.10) and (0.25–0.35). By optimizing routing planning, operating across dedicated lines of different speed grades can achieve self-cleaning of central hollow tread wear over time. According to the inherent rigid-flex coupling relationship, geometric nonlinearities of worn wheel-rail contact should be avoided as much as possible for HSR practices. Only under weak coupling interfaces in the floor frame can the structural integrity of an aluminum alloy car body be ensured.

Keywords: large-scale complex nonlinear dynamic system; multidiscipline design optimization; weak coupling interface; rigid-flex coupling simulation technique; modal stress recovery

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1. Introduction

As for high-tech manufacturing industries such as HSRS (High Speed Rail Stock), the dynamic design methodology should be actively recommended and introduced to better develop the corresponding large-scale complex nonlinear dynamic systems. Furthermore, by applying efficient tools such as PODA (Proper Orthogonal Decomposition Approach) or MMRT (Modal Modification Responding Technique), weak coupling interfaces are necessary to be constructed between different disciplines, by which the large-scale MDO (Multidiscipline Design Optimization) technical platform can be established, steering the system design in a more preferable direction.

Multidiscipline Design Optimization Solutions Manual

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