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Topology and sizing optimisation of integral bus chassis with the use of a cooperative coevolutionary genetic algorithm with independent ground structures

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Abstract

This paper focuses on the simultaneous topology and sizing optimisation of an integral bus chassis by treating it as a discrete variable optimisation problem. The objective is to reduce the mass. The torsional stiffness, the foundational frequency and the max Von Mises stress under full-loaded bending case are constrained to be no worse than the original bus. Meanwhile, some essential functional and manufacturing requirements are considered.

The challenges of solving the problem come from several reasons. First, large number of discrete variables are involved which would deteriorate the performance of the optimisation algorithm. Second, design constraints are diverse including performance constraints, manufacturing constraints, functional constraints and so on. Third, since a bus undergoes various loadings during lifetime, multiple conditions need to be handled, such as linear static analysis, eigenvalue extraction, etc.

A special architecture of CCGA that is suitable for simultaneous topology and sizing optimisation is introduced to handle the problem of large number of discrete variables. Since functional and manufacturing constraints are usually difficult to be expressed in rigorous mathematical equations, actions are taken before the optimisation by appropriately defining the design spaces and grouping variables to meet these constraints. In order to define design spaces and constraints more flexibly for topology and sizing optimisation, a strategy called independent ground structures (IGS) is presented, where different ground structures are constructed for topology optimisation and sizing optimisation independently. IGS strategy is integrated into the CCGA architecture, and a method named CCGA-IGS is presented, which was implemented on the bus chassis frame. Moreover, a strategy is presented to automatically reload the uniformly distributed loads when the topology of the chassis is changed.

The result shows that the proposed architecture is efficient to solve the problem. Compared with the original bus body frame, the bus body frame with the optimal chassis is 246.45 kg (8.42% of the original bus) lighter, while the torsional stiffness, the foundational frequency and the max Von Mises stress are not worse. Meanwhile, the optimal chassis satisfies the functional and manufacturing requirements considered in this paper.