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Crash Optimization of Automobile Frontal and Side Structures Using Equivalent Static Loads

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Abstract

Many commercial automobile industries are seeking to design the automobile structure for improvement of passenger safety as well as reduction of the mass of the automobile. Optimization can be employed to accommodate the crash environment. The automobile crash optimization problem has large nonlinearity in analysis while the analysis is carried out in the time domain. Although the performance of the computer has been significantly improved, automobile crash optimization still needs considerable computational cost. The equivalent static loads (ESLs) method has been developed for such nonlinear dynamic response structural optimization. The ESLs are static loads that generate the same displacement in the linear static analysis as those of the nonlinear dynamic analysis at a certain time step. The ESLs are generated at all the time steps and used as multiple external forces in linear static response structural optimization. Nonlinear analysis and linear static response optimization using ESLs are carried out sequentially until the convergence criteria are satisfied. A new ESLs method is proposed for automobile crash optimization and the proposed method is verified using two practical examples. Crash optimization under a frontal impact performed to minimize the mass, and the thicknesses of the structure are determined to satisfy the relative distance constraints. The side structure of an automobile is optimized under a side impact test. The mass is minimized while the regulation of Insurance Institute for Highway Safety (IIHS) is satisfied. The regulation is the limit of the maximum intrusion that is the relative distance between the B-pillar and the center line of the seat. The resultant designs are discussed from a practical viewpoint.

Keywords: Structural optimization, equivalent static loads (ESLs), frontal structure, side impact test, moving deformable barrier (MDB).