● 발표 주제

내충돌성 향상을 위한 자동차 Crash-Box 위상최적 설계와 복합재 도어의 최적설계

Design Optimization of an Automotive Crash-box and a Composite Door for Improving Crash Performance

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● 발표초록

Since the role of a crash-box structure is to absorb the crash energy, its design optimization is necessary to meet less weight and higher safety. However, due to the high nonlinearity in material behaviors and dynamic responses, to satisfy the goals is difficult. The structural optimization with non-linear dynamic responses is generally classified into the gradient-based optimization, the non-gradient-based one, and the equivalent-static-loads method. Practical or large-scale examples are seldom found to be used by gradient-based optimization because of the computational cost. Additionally, optimization results obtained by non-gradient-based optimization are highly dependent on the number of samplings, which is related to the number of design variables. In order to overcome these difficulties, a combination of equivalent-static-loads (ESLs) and gradient-based linear static structural optimization is applied. The ESLs are the loads that generate the same response field of linear static analysis as that of nonlinear dynamic analysis at each time step. The ESLs are imposed as external loads to do the linear static structural optimization. This process continues until meeting the convergence criterion. The structural optimization of a nonlinear dynamic problem with highly nonlinear geometry and material behaviors with rate dependent plasticity, damage initiation, damage evolution up to the element removal problem is expanded. The research goals are to obtain an efficient optimum topology of thin-walled structure under the axial crush and to control its crashworthiness by using the ESLs method. The obtained topology optimization results would be the real clue to design the most efficient and light crash box structure under the same working condition. Furthermore, the methodology can be applied to the structures with highly nonlinear behaviors in terms of material, geometry, vibratory and combined crash loadings. In another effort to save the weight of electric vehicles, the applications of fiber reinforced laminated composite materials which show good structural characteristics such as light weight and higher stiffness for automotive structures such as bumpers, doors or frames increase recently.
In this study, the topology optimization of fiber reinforced laminated composite plates and shell structures which appear on the composite door structures of electric vehicles including several manufacturing constraints that can be found from several fabrication methods actually applied in industries are developed considering a side collision impact load. The topology optimization is based on a finite element method coupled with interpolation schemes with penalization through the so-called discrete material optimization (DMO) method. There were 4 DMO variables (0o, ±45o, and 90o) for the composite laminates, and void indicates that the soft thin laminate has been chosen. The optimum thickness and fiber orientation of laminated composite door panels were calculated on the basis of topology optimization subjected to a high side impact load under a rigidity constraint, like compliance or allowable stresses. After the thickness and fiber orientation of a composite door was obtained, topology optimization was performed again to find out the optimum layouts of laminated composite stiffeners attached to the composite curved door panel in order to maximize the impact bearing capacity.

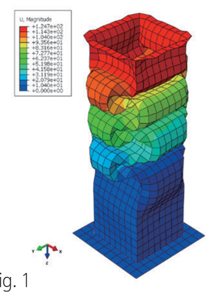

Fig. 1
Crushed thin-walled structure

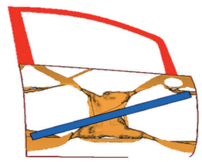

Fig. 2
Topology optimization of composite door and impact beam structures