Topology and Topometry Optimization of Crash Applications with the Equivalent Static Load Method

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Abstract

This paper deals with topology and topometry optimization of structures under highly nonlinear dynamic loading such as crash using equivalent static loads.

The basic idea of the "Equivalent Static Load"- Method (ESL) is, to divide the original nonlinear dynamic optimization problem into an iterative "linear optimization ↔ nonlinear analysis" process. The displacement field of the nonlinear dynamic analysis is transformed to equivalent linear static loads for a variety of time steps. This leads to an optimization with multiple linear static load case. In an outer loop the nonlinear analysis is repeated to correct and adapt the displacement field. On the idea of equivalent static loads there are several previous papers, e.g. Shin MK, Park KJ, Park GJ: Optimization of structures with nonlinear behavior using equivalent load. Comp. Meth. Appl. Math.,196, p.1154-1167, 2007.

This paper reports about experiences in the application of the ESL methodology on industrial problems from the automotive industry. For the nonlinear dynamic analysis LS-DYNA is used, for linear topology and topometry optimization GENESIS from Vanderplaats R&D is applied. The investigations have been performed within a research project, founded by the association BMBF, with several partners from German automotive companies.
On the application of the method on large scale problems numerous problems are encountered. Setting up a fully automated and robust process on an HPC cluster with nested linear and nonlinear finite element analysis and optimization for multiple load cases was a challenging task.

The general objective of the investigations was to evaluate the suitability of the method for different types of crash and impact problems. The appraisement is with respect to quality and usability of the results and with respect to the numerical costs.