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Topology optimization considering the requirements of deep-drawn sheet metals

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Abstract

Topology-optimized designs for minimum compliance or minimum stress at minimum mass are often framework structures due to their homogeneous stress distribution over the cross section and therefore the best possible material utilization. From the manufacturing's point of view complex framework structures, which often develops during topology optimization, are difficult to manufacture because of possible undercuts. Manufacturing of these designs is often only possible by joining of numerous components or by 3D printing.

For mass production sheet metal parts manufactured by deep drawing are often more efficient concerning the costs in relation to their performance. Therefore we implemented a manufacturing constraint to the 3D topology optimization based on the density method ensuring that thin walled structure results. Thereby more flexibility for the mid surface design and also for cut-outs is reached compared to the optimization based on CAD-parameters. Also a variable thickness distribution for tailored blanks can be achieved.

The mid surface is calculated from the element densities of the voxel mesh. Afterwards the sensitivities far away from the mid surface are penalized in order to obtain a thin walled structure. To overcome convergence problems a change of the SIMP-Penalty-Exponent and an alternation of the desired wall thickness during are optimization process is performed. Thus the mid surface can move continuously to an optimized design with optimized cut-outs.

It is checked that the discretization with three linear voxel elements across the wall thickness is sufficient for displacements and stresses due to the modelling accuracy.

Results for deep drawing structures with optimized topologies at constant wall thickness and without undercuts are compared with optimized structures without manufacturing restriction due to their performance.

Finally, we conclude that this manufacturing restriction is a good option to successfully apply topology optimization for designing industrially produced sheet metals.