Shape Optimization of a Crashbox using HyperMorph and LS-OPT

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Abstract:

The aim of this paper is to demonstrate how to improve the performance of a crashbox by the application of shape optimization using HyperMorph and LS-OPT. Two load cases for the crashbox are considered: low speed front crash with initial load in x-direction and low speed crash with initial load 10° rotated with respect to the x-axis. Possible beads and geometry variations are parameterized with HyperMorph. The parameters that define the shape variations in HyperMorph are controlled by LS-OPT and be exchanged via a dedicated interface.
The main quality criterion for the crashbox is the smoothness of the force values which occur during the energy absorption. This means, a force-intrusion curve with a horizontal line, after a specific force level is reached, would be the ideal case. The formulation of the optimization problem takes this into account by minimizing the difference between the maximum and the minimum force values of the force-intrusion curve during the folding process. Simultaneously several restrictions regarding the producibility and the folding mechanism have to be considered.

Keywords:

Crashbox, Shape-Optimization, LS-OPT, HyperMorph, LS-DYNA

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1 Optimization Problem and Load Cases

• Objective	$maxF - minF = \Delta F$, (during the folding process) ΔF (loadcase1)+ ΔF (loadcase2) to be minimized
• Constraints	➢ no spot-welds allowed, where beads are located ➢ minimum distance between spot-weld and bead ➢ size (depth) of beads ➢ Folding process should start on the side of the impact. For this, the crash box is subdivided into three parts and the history of the internal energy is monitored for each part. The constraint formulation for the optimization is as follows: ▪ $IntEnergyPart1(t_1)$- $Int.EnergiePart2(t_1) > 0$ ▪ $IntEnergyPart2(t_1)$- $Int.EnergiePart3(t_1) > 0$ t_1 is a specific time at the beginning of the folding process
• Parameters	➢ geometry parameters of the beads evaluated by LS-OPT and transformed to HyperMorph (15 variables)

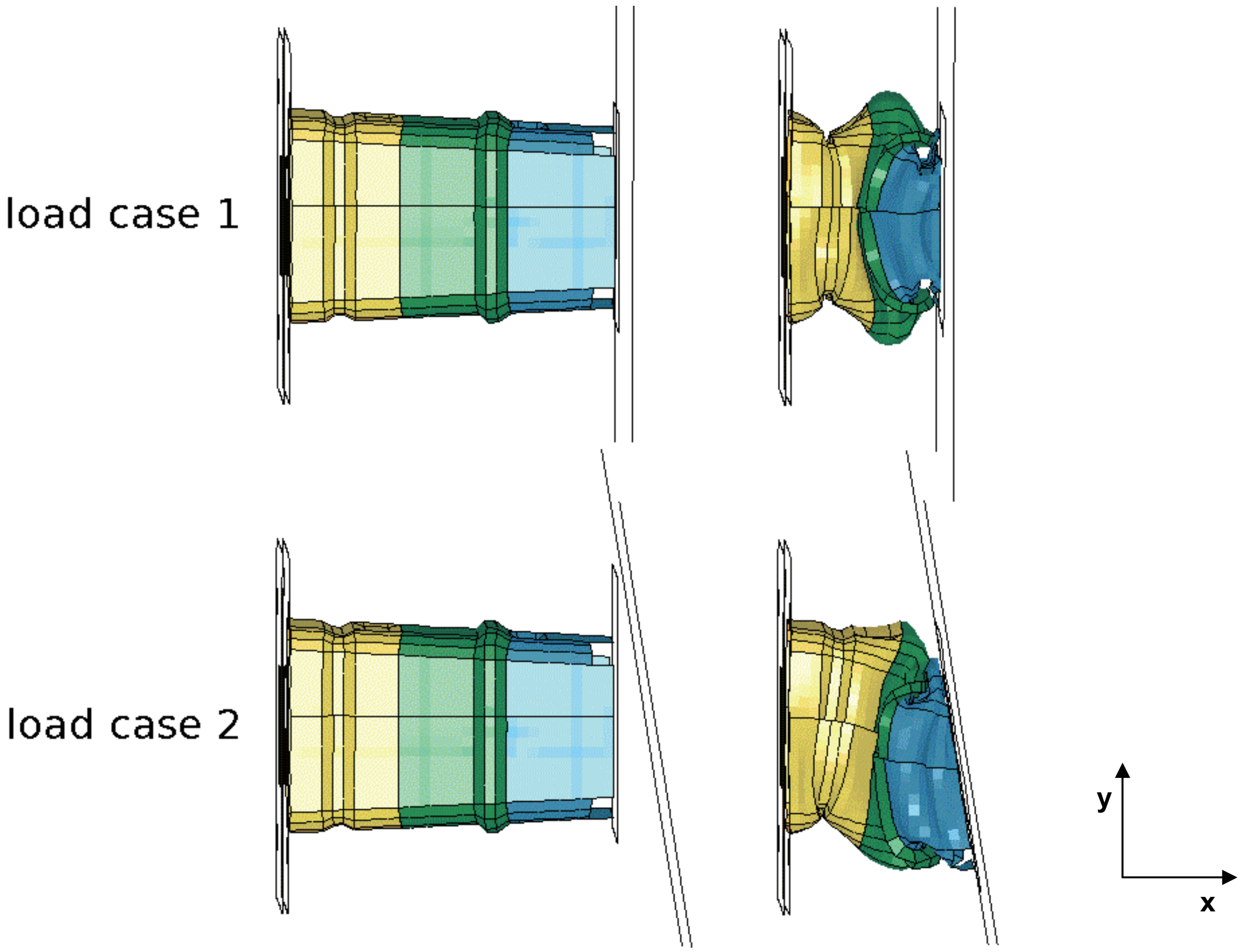

Figure 1: In load case 1 the load is applied in x-direction; in load case2 the load is applied 10° rotated with respect to x-direction

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2 Results

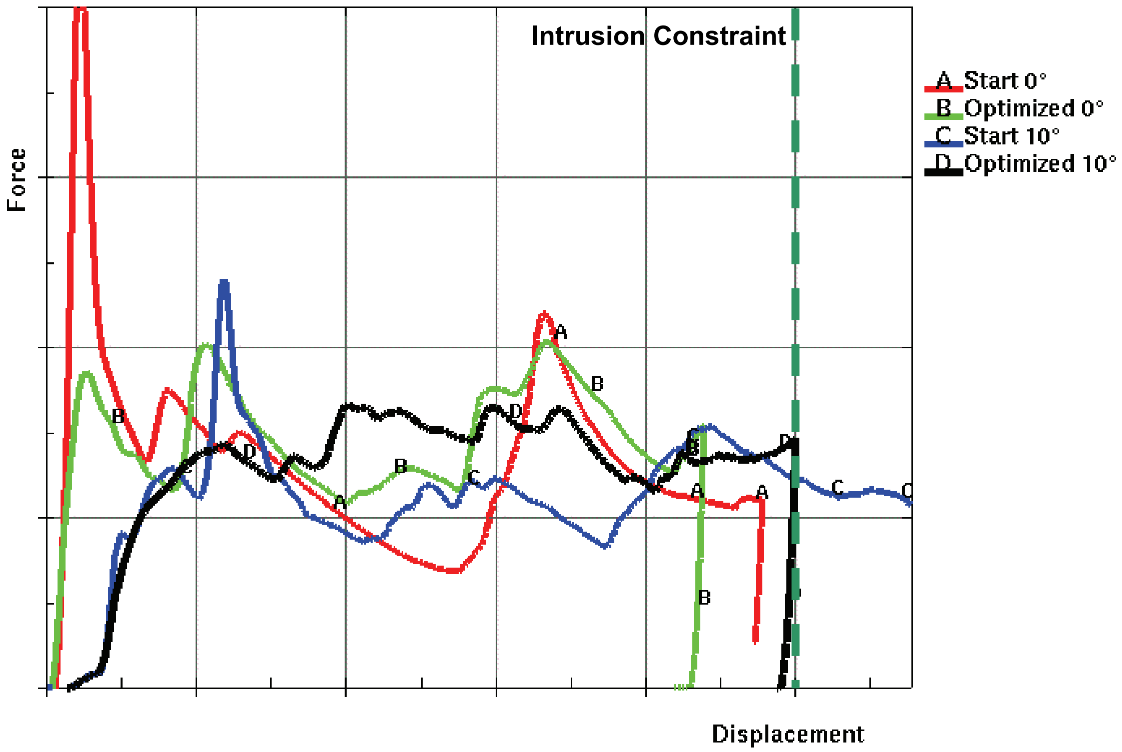

Figure 2: Development of the force-displacement curves of the crash box as a result of the optimization. The curves A and C are from the baseline design, the curves B and D result from the optimized crash box shape for load case 1 and load case 2 respectively. The dashed line represents an intrusion constraint which is violated for the baseline design (load case 2). The difference of the minimum and maximum force during folding is reduced from 2.8 to 1 for load case 1 and from 2.36 to 1 for load case2. Thereby the violation of the intrusion constraint is disappeared.

3 Conclusions

In this study shape-optimization with HyperMorph and LS-OPT has been applied. In LS-OPT the successive response surface scheme (SRSM) with linear polynomials was used, compare *Stander et al.* [1].Therefore, 15 design variables and 6 constraints were introduced. The convergence of the optimization algorithm was rather difficult and about 20 iterations were necessary to achieve stationary values. Finally, the optimization completed with a significant improvement of the performance of the crash box, see Figure 2.

A limitation of the application of morphing is the restrictions with respect to element size and element quality for the FE-simulation. This reduces the possibilities of geometry changes, because no remeshing is applied. Small element sizes are particularly a problem for explicit FE-calculations.

4 Literatur

[1] *Stander, N. et al.:* LS-OPT User´s Manual 2004, Livermore Software Technology Corporation

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