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Using a binary material model for stress constraints and nonlinearities up to crash in topology optimization

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Abstract
Nowadays the development of mechanical components is driven by ambitious targets. Engineers have to fulfill technical requirements under the restrictions of minimizing costs and reducing weight for mechanical components simultaneously. Therefore in the last years developed and investigated optimization methods have been integrated in the development process of industrial companies. Today, especially topology optimization methods gain in importance and are often used for developing casting parts.

Using stress or strain-energy information for sensitivities is the basic idea in all topology optimization methods. The method SIMP, today's standard in industry, uses continuous material modeling and gradient algorithms. ESO/BESO is using discrete modeling: specific algorithms depending on the individual approaches direct, gradient or interpolated information to change the structure.

The new Topology Optimization method is based on two simple, but powerful ideas. No gradient information is necessary. The first implemented ideas are similar to BESO. The lowest stressed elements are removed from the structure. At the highest stressed elements - *hotspots* in engineering terminology- material is added. This mechanism has its analogy in nature similar to the development and growth of trees and is also grounded in experiences from solving engineering problems. Other ideas are different to BESO. BESO tries to achieve a full stressed design. For BESO the compliance-volume product can be assumed as an objective function. Different to BESO, the new Topology Optimization method uses the minimization of volumes as an objective function. In the new Topology Optimization method a controller mechanism calculates the step sizes of added or removed material depending to the progress of the constraints in the optimization. This approach allows an easy implementation of manufacturing restrictions and response functions.

Developed for industrial applications, the approach solves many academic reference problems better than other available commercial optimization tools. In the next steps, stress constraints and optimization runs with plastic material are tested separately. Based on good results, all necessary response functions are used together in optimization runs during the normal industrial development process. Now it is possible, to fulfill directly all specifications in the first concept phase and in topology optimizations. So, more weight reductions, comparing with the results of the conventional industrial used topology optimization, is the effect.

The current field of research work is to investigate topology optimization with a crash load case. In this topology optimization an explicit FEM analysis is integrated.

The paper and talks shows the current status of this approach of topology optimization with academic and industrial examples.