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Rule generation for optimal topology changes of crash-loaded structures

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This contribution deals with the generation of special heuristics (rules) coming from engineering people. The application area of these rules is the topology optimization of crash-loaded structures considering all relevant behaviours. Here, we have to handle long computer times and inefficient possibilities for generation of sensitivities. The reason is the highly non-linear behaviour of the explicit finite element calculation coming from the existence of structural contacts, complex material behaviour and physical bifurcations. If the consideration of all relevant crashworthiness behaviours is required, single mathematical based topology optimization procedures are not able to support real engineering tasks. The concept to overcome this problem is the combination of mathematical approaches for shape optimization and heuristics for topology changes. This hierarchical approach is presented in another independent contribution [1]. The basis for the generation of design rules is the expert knowledge of several development and research groups of automotive companies (in our study: Adam Opel AG, Porsche AG, Daimler AG, Volkswagen AG). The application field is the development of extrusion profiles in crashworthiness structures. At the beginning, brainstorming meetings were organized in order to find all relevant expert knowledge in this field. We selected more than 150 different engineering ideas for the crashworthiness design. Based on these results we structured the ideas and generated concepts for heuristic algorithms. The results are several heuristic algorithms like “delete unnecessary walls”, “support fast deforming walls”, “remove small chambers” or “balance energy density”. All heuristics work with the results of a full crash simulation of the structure (displacements, velocities and acceleration of finite element nodes, deformation energies in components, forces in special parts …). In order to have a clear procedure for selection of one rule for the next topology design change, each heuristic calculates a priority value. The priority values are calculated based on the significance analysis for the single heuristic. For the selected rule, the design topology change is done based on geometry generation supported by graph theory and finite element pre-processing [2].
Beside the description of the approach, this contribution discusses the problems using heuristics in the structural optimization.

References

[1] Ortmann, C., Schumacher, A.: " Hierarchical shape and topology optimization of crash-loaded structures” 10th World Congress on Structural and Multidisciplinary Optimization, Orlando-Florida, May 19-24, 2013
[2] Ortmann, C.; Schumacher, A.: „"Graph and heuristic based topology optimization of crash loaded structures", to appear in Journal of Structural and Multidisciplinary Optimization, 2013

Keywords
Topology optimization – Rule-based approach – Heuristic approach – Crashworthiness – Expert knowledge