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Multi-Objective Shape Optimization of a car inner hood panel using premeshed parameterized forms

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We propose in this work a shape optimization approach coupling the geometric optimization with its topological counterpart. We propose to integrate premeshed parameterized elementary forms (Figure.1) into 3D sheet meshed surfaces.

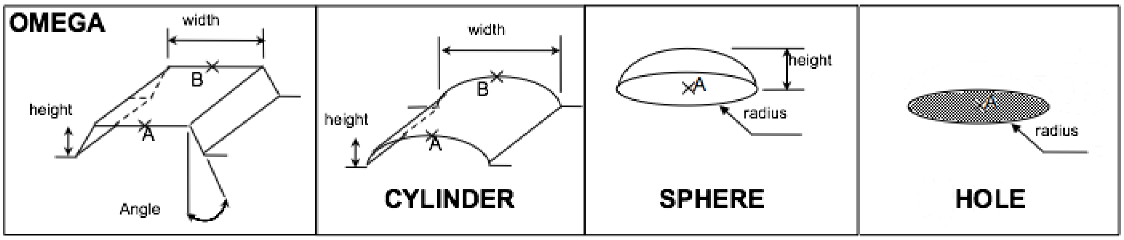

Figure 1. Parameterized elementary forms Library

Design optimization in engineering usually refers either to shape or to topology optimization. Shape optimization allows variations of the boundary albeit without modifying the topology, restraining thus the shapes variety and demanding an a priori judicious intuition in the choice of design variables. The topology optimization is free of this constraint, as it makes no assumptions neither on the shape nor on the number of boundaries. However, one of the main difficulties in topology optimization is to translate resulting shapes into CAD models complying with manufacturing constraints to be used in the computational workflow involving refined finite element simulations of multiple physical phenomena.

The proposed approach is entirely based on the mesh primitives. We focus on thin shell structures encountered in automotive industry. The goal is to design stiffening patterns without any constraint on the topology: the stiffeners may be of arbitrary form and they may intersect freely. We have developed a set of operators acting on the mesh allowing a constant evolution of the topology guided by optimization. Thus, even if the topology may vary, the resulting shapes comply with the CAD representation by construction (Figure 2).

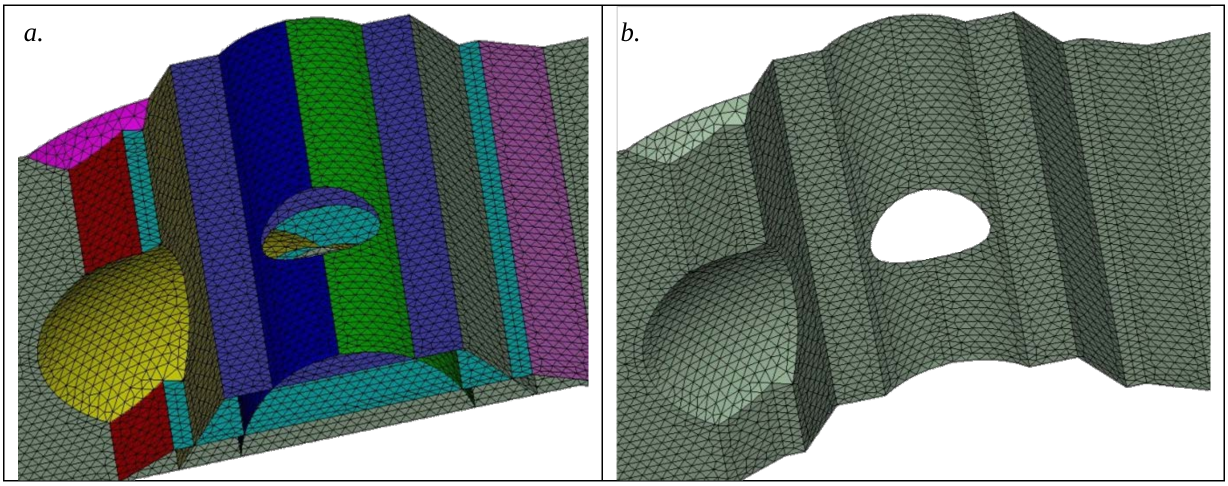

Figure 2. - 3D surface meshed defined in terms of set operations on elementary shapes
a. intersecting elementary forms, b. resulting surface.

The computation of gradients of the quantities of interest (objective functions, constraints) is then possible. We illustrate our approach with the design of a car inner hood panel for three competing criteria:

- compliance,
- crashworthiness *(HIC: Head Injury Criteria)*,
- acoustics.

Three levels of parameters are introduced:

- number and types on stiffeners based on the parameterized elementary forms library,
- positions of the stiffeners (ex. position of points A and B in Figure 1.),
- shape parameters of the selected parameterized forms.

The problem is then defined as a multi-objective multi-scale shape optimization.

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REFERENCES

[1] G.Allaire. *Conception Optimale de structures*, Springer, 2007.

[2] P.Breitkopf, H.Naceur, A.Rassineux, P.Villon. *Moving least squares response surface approximation: formulation and metal forming applications*, Computers and Structures, 83(17-18) :1411-1428, 2005.

[3] D.Weiss, B.Sonntag, T.Krumenaker, DR.D.Nowottny, Dr.J.Sprave, W.Hipp. *Geometry-based Topology Optimization - Improving Head Impact Performance of an Engine Hood*, 7th European LS-DYNA Conference, 2009.

[4] P.Breitkopf, R.Filomeno Cœlho. *Multidisciplinary Design Optimization in Computational Mechanics*, Wiley & Interscience, 2010.

[5] M.P.Bendsøe, O.Sigmund. *Topology optimization: theory, methods and applications*, Springer, 2004.