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TOPOLOGY OPTIMIZATION OF STRUCTURES – AN OVERVIEW

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ABSTRACT

Topology optimization is a relatively new but extremely rapidly expanding research field, which has interesting theoretical implications in mathematics, mechanics, multi-physics and computer science, but also important practical applications by the manufacturing (in particular, car and aerospace) industries, and is likely to have a significant role in micro- and nano-technologies.

The first paper on topology optimization was published over a century ago by the versatile Australian inventor Michell˙(1904) who derived optimality criteria for the least-weight layout of trusses. Some seventy years later the author and his research group extended Michell's theory to grillages (beam systems) in a number of papers. Based on these applications, Prager and Rozvany (2) formulated the first general theory of topology optimization, termed "optimal layout theory". They applied this primarily to exact, analytical optimization of grid-like structures, but it has also important implications for numerical methods and continuum-type structures.

Starting with the landmark paper of Bendsoe and Kikuchi (3), numerical methods for topology optimization have been investigated extensively since the late nineteen-eighties.

The presently most popular numerical, FE-based topology optimization method is the SIMP method, which was developed in the late eighties. It is sometimes called "material interpolation", "artificial material", "power law", or "density" method, but "SIMP" is now used fairly universally. The term "SIMP" stands for **S**olid **I**sotropic **M**icrostructure (or **M**aterial) with **P**enalization of intermediate densities. The basic idea of this approach was proposed by Bendsoe (4), whilst the full computational details of this method were developed at the Essen University by Zhou and Rozvany (5). The term

"SIMP" was coined later by the author, and first introduced in a paper by Rozvany et al. (6).

The main aim of this keynote lecture is to compare critically the SIMP method with other topology optimization methods, such as homogenization methods (OMP = Optimal Microstructures with Penalty, NOM = Near Optimal Microstructures), Level Set Methods and a heuristic method called ESO. The historical background, validity and efficiency of these methods will be discussed in detail.

The present state of so-called "checkerboard control" (avoidance of a frequent computational error in topology optimization) will also be examined.

Methods for checking on the validity of optimal topologies derived by various methods will also be considered and the concept of extended optimality briefly reviewed.

Finally, some examples of industrial applications of topology optimization will be given.

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