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H-DGTP—a Heaviside-Function Based Directional Growth Topology Parameterization for design Optimization of Stiffener's Layout and Heights of Thin-Walled Structures

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For a given loading, the stiffness of a plate or shell structure can be increased significantly by the addition of ribs or stiffeners. Research work on structural optimization of plates and shells has therefore identified the rib location by thickness distribution using an optimization technique [1, 2]. However, such plate design with varying thickness is practically infeasible other than in very specific circumstances and does not give clear location of ribs. How to get the optimum location and size of the ribs is also a challenge.

Topology optimization is used to improve an initial design by variation of its geometrical and material properties with regard to a set of prescribed objectives and constraints. During the past decades topology optimization has been extensively developed and has been applied in industrial succeed in many circumstances. While the performance of a structure can be improved via the optimization, manufacturing also needs to be carefully treated. Today several methods such as casting, forming, molding and machining are available to shape metals into final products or components. In the engineering machinery industry, lots of plate or shell structures with stiffness can be made by casting, so it is very important to propose a method to design the stiffness of a plate or shell structure considering the cast constraints.

Much effort has been made to consider the cast constraints in the topology optimization. To the authors' best knowledge, Harzheim [3] first successfully incorporated the molding constraints of casting process into topology optimization based on CAO and SKO. Xia [4] proposed a level set based method for the optimization of cast parts. Zhou et al [5]. proposed a mathematical formulation of the molding constraint that constraints the material densities in the lower positions to be bigger than those in the upper positions. However, this method makes the optimization problem costly to solve for too much constraints. In order to solve this problem, Gersborg et al [6] proposed an explicit parameterization based on Heaviside function.

In this paper, we proposed a new explicit parameterization to design the stiffness of a plate or shell structure considering the cast constraints. The basic idea is the relative density of reinforcement is coincident with the mapping element in base surface, while the height of reinforcement is described by Heaviside function. It is suitable for non-uniform mesh and some examples show the validity of this method.

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