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IMPOSING 5-AXIS MILLING CONSTRAINTS IN DENSITY-BASED TOPOLOGY OPTIMIZATION

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Abstract: This contribution presents a formulation to guarantee manufacturability by 5-axis milling processes in density-based topology optimization, and aspects of its implementation in a commercial topology optimization environment. Considering manufacturing restrictions at an early stage in the design process is important, as designs generated without such restrictions are likely to lead towards design concepts that prove highly suboptimal when manufacturing considerations are introduced at a later design stage. Various manufacturing constraints have already been developed for topology optimization, for operations ranging from casting to rolling to additive manufacturing. However, for 5-axis milling, which represents one of the most prominent and often used manufacturing techniques for metal components, thus far no adequate approach was available. In this process, 3 relative translations and 2 rotations are possible between a cutting tool and the workpiece. The amount of possible operations forms a challenge in formulating an efficient manufacturing constraint for use in topology optimization. In this contribution, we present our method to impose 5-axis milling restrictions, using a filtering approach in a density-based (SIMP) topology optimization setting. Next to presenting its formulation, we discuss ways to control the tool orientations and cutter geometry, as well as implementation considerations for arbitrary meshes in a commercial software environment. Numerical examples will be presented in 2D (3-axis milling) and 3D for the full 5-axis case, using Autodesk Nastran.