Simulation-Guided Lattice Geometry Optimization of Metal Marine Propeller for Additive Manufacturing

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One of the most promising emerging technologies is additive manufacturing (AM), which offers major advantages in manufacturing of complex components, enhanced performance, material savings, and process control, when compared to conventional processes.This thesis focuses on the design of an exemplary marine propeller to leverage the advantages of AM, specifically via simulation-guided design of an internal lattice structure.

For this purpose a B-series Wageningen three-blade propeller model, provided by NSWC Carderock, was used as a baseline. Its open water loading conditions were calculated numerically using OpenFOAM® Computational Fluid Dynamics (CFD) software. The CFD results were verified using the provided test data, which showed a conformity of 97%. The derived loads were introduced to the Finite Element Analysis (FEA) based optimization utility of Autodesk ® Netfabb Ultimate, in order to identify the optimum lattice geometry for this application. The design limitations were dictated by the material (316SL stainless steel), the metal additive manufacturing process, and the propeller outer geometry.

The design with the best performance was a hexagonal grid lattice with 1mm wall thickness, which was prescribed as a manufacturing constraint (thinnest wall. The material volume was reduced by 57%, while exhibiting a safety factor 7.5 based on the material properties and the simulated loads.

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