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Topology Optimization of Heat Exchanger Manifolds for Aircraft

Authors : Hanjong Kim, Changwan Han, Seonghun Park

Abstract : Heat exchanger manifolds in aircraft play an important role in evenly distributing the fluid entering through the inlet to the heat transfer unit. In order to achieve this requirement, the manifold should be designed to have a light weight by withstanding high internal pressure. Therefore, this study aims at minimizing the weight of the heat exchanger manifold through topology optimization. For topology optimization, the initial design space was created with the inner surface extracted from the currently used manifold model and with the outer surface having a dimension of 243.42 mm of X 74.09 mm X 65 mm. This design space solid model was transformed into a finite element model with a maximum tetrahedron mesh size of 2 mm using ANSYS Workbench. Then, topology optimization was performed under the boundary conditions of an internal pressure of 5.5 MPa and the fixed support for rectangular inlet boundaries by SIMULIA TOSCA. This topology optimization produced the minimized finial volume of the manifold (i.e., 7.3% of the initial volume) based on the given constraints (i.e., 6% of the initial volume) and the objective function (i.e., maximizing manifold stiffness). Weight of the optimized model was 6.7% lighter than the currently used manifold, but after smoothing the topology optimized model, this difference would be bigger. The current optimized model has uneven thickness and skeleton-shaped outer surface to reduce stress concentration. We are currently simplifying the optimized model shape with spline interpolations by reflecting the design characteristics in thickness and skeletal structures from the optimized model. This simplified model will be validated again by calculating both stress distributions and weight reduction and then the validated model will be manufactured using 3D printing processes.

Keywords : topology optimization, manifold, heat exchanger, 3D printing
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