Development of a Beta Function Based Topology Optimization Procedure

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Abstract: *A novel finite element based topology optimization scheme has been developed and implemented through the use of Abaqus user subroutines. The procedure is based on an iterative material redistribution scheme in which the desired material distribution at each iteration is imposed. A family of Beta probability density functions is utilized to provide a gradual transition from an initial unimodal material density distribution to a bimodal distribution of fully dense and essentially void regions. The efficiency and validity of the scheme is demonstrated through a number of 2-D and 3-D test cases for which the optimal topology is known from analytic optimality criteria. These test cases include classical minimum weight Michell structures as well as newly derived optimal topologies for 3-D structures. The described method is the subject of international patent application number PCT/US2006/062302.*

To visualize the converged finite element results, procedures are developed to convert the final bimodal material distribution data into contour surfaces of constant density. These contours are then saved in a standardized CAD format (STL) that are imported into commercial CAD software. The CAD models are used directly in rapid manufacturing equipment for the production of prototype parts. Physical prototypes of optimized structures have been manufactured using Laser Engineered Net-Shaping™ (LENS®) and Dimension SST 3D-Printing. In addition to the test cases for which optimal topologies are known from analytic optimality criteria, application of the method to the design of an aerospace component will be presented.

Keywords: Design Optimization, Minimum-Weight Structures, Optimization, Postprocessing.

1. Introduction

Several finite element based optimization schemes have been demonstrated to determine minimum weight structural topologies (1-4). Recent work at the University of Rhode Island (5,6) has led to the development of schemes that have been implemented in Abaqus through the use of user subroutines (7). In this paper, topology optimization using prescribed redistribution is shown to provide a computationally efficient procedure. This scheme provides a robust optimization tool that can be exercised within the Abaqus/CAE user interface.