

Accepted Manuscript

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M. Shin, D.A. Tortorelli, J.A. Norato

PII: S0045-7825(15)00174-7

DOI: <http://dx.doi.org/10.1016/j.cma.2015.05.008>

Reference: CMA 10621

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date: 10 October 2014

Revised date: 2 May 2015

Accepted date: 6 May 2015

Please cite this article as: M. Shin, D.A. Tortorelli, J.A. Norato, Optimal shape design of axisymmetric structures subject to asymmetric loading, *Comput. Methods Appl. Mech. Engrg.* (2015), <http://dx.doi.org/10.1016/j.cma.2015.05.008>

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Optimal shape design of axisymmetric structures subject to asymmetric loading

M. Shin^a, D. A. Tortorelli^a, J. A. Norato^{b,*}

^a*Department of Mechanical Science and Engineering, University of Illinois at
Urbana-Champaign, 1206 West Green Street, MC-244, Urbana, IL 61801, United States*
^b*Department of Mechanical Engineering, The University of Connecticut, 191 Auditorium
Road, U-3139, Storrs, CT 06269*

Abstract

This article describes an efficient method for the shape optimization of axisymmetric structures under asymmetric loads. Our method employs the semi-analytical method for both the primal and adjoint sensitivity analyses to convert the three-dimensional problem into a more manageable two-dimensional problem. By using the Kronecker product and the matrix and vector representations of fourth- and second-order tensors respectively, we obtain finite element formulas for the primal and sensitivity analyses that are succinct, can be readily programmed, and accommodate different element orders and topologies with minimal changes to the code. Instead of imposing local stress constraints on the surface of the component, as it is often done in shape optimization methods that update the design by deforming the mesh, we employ the stress p -norm over the body to approximate the maximum stress—a technique we borrow from recent developments in topology optimization. By doing this, we need not track stresses at specific locations of the body surface, nor impose many local stress constraints. To assess the procedure, the shape of axisymmetric cantilevers subject to a variety of loadings is optimized to minimize their mass subject to von Mises stress constraints; these designs are compared to analytical solutions obtained from beam theory. We also present a shaft shoulder design example

*Corresponding author. Phone: +1 (860)486-2345. Fax: (860)486-5088. E-mail address: norato@engr.uconn.edu.

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