DESIGN SENSITIVITY ANALYSIS AND OPTIMIZATION OF EULERIAN DESIGN PROBLEMS

N. H. Kim[a] and **Y. Chang**[a]

[a]Department of Mechanical and Aerospace Engineering
PO Box 116250
University of Florida
Gainesville, Florida 32611-6250
nkim@ufl.edu

In this paper, a new methodology of shape optimization is proposed that adopts advantages of both conventional shape optimization and topology optimization methods. In structural analysis, the geometric model is overlaid on top of regularly meshed finite elements[Figure 1(a)]. The finite elements are fixed in the design space, while the geometric model is changed according to the shape design. The finite elements that belong inside of the geometric model have a full magnitude of material density, while the finite elements out of the model have a zero magnitude of material density (void). The finite elements on the edge of the model have a material density proportional to the area ratio between the material and void parts. Thus, the finite elements on the edge have a material density between full material and void [See Figure 1(b)].

In shape optimization, the shape change of the structural model causes the area ratio change of the finite elements on the edge. As the structural shape changes, a new area ratio is calculated for those element on the edge. In addition, some elements leave the structural domain, while some elements enter the structural domain. Thus, book-keeping is an important part of the proposed approach. However, this approach does not require any mesh update process and the solution accuracy can be maintained during the whole design process because the same size of finite element is used consistently.

A mathematical difficulty of the proposed method is how to represent the effects of shape change into the material property change. Since the shape design variables are chosen from the geometric parameters, the explicit contribution of the boundary curve shape to the area ratio of the boundary element is calculated based on the geometric relation. Accordingly, the boundary shape design velocity is related to the area ratio of the boundary elements, which is used in design sensitivity calculation. Thus, complicated shape design sensitivity formulation can be taken care of using a simple parametric design sensitivity formulation. In addition, the numerical integration involved in the sensitivity calculation is limited only for those elements on the boundary, which provides an efficiency of the proposed approach.

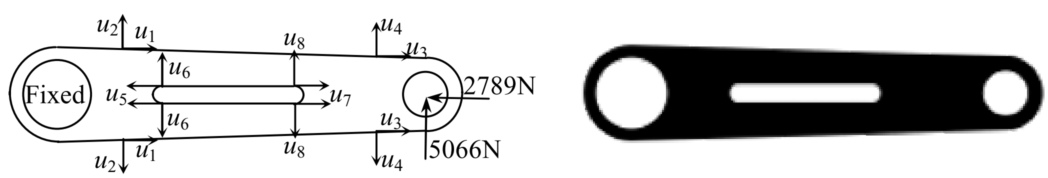

Figure 1. (a) CAD model and design parameters (b) Geometric representation using shape density

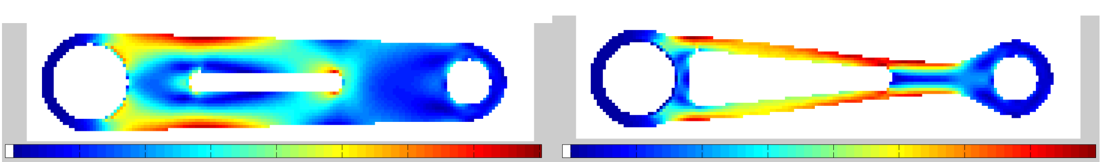

Figure 2. (a) FE results at initial design (b) FE results at optimum design