11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Design and topology optimisation of fractal vasculature

Che-Cheng Chang[1], Shiwei Zhou[2], Qing Li[1]

[1] School of Aerospace, Mechanical and Mechatronic Engineering, The University of Sydney, Sydney, NSW 2006, Australia, checheng.chang@sydney.edu.au
[2] Centre for Innovative Structures and Materials, School of Civil, Environmental and Chemical Engineering, RMIT University, GPO Box 2476, Melbourne 3001, Australia, shiwei.zhou@rmit.edu.au

Abstract

Fractal patterns develop naturally in vascular systems. The formation of fractal patterns is supposedly driven by self-optimisation to maximise transportation rate. To test this hypothesis, we have formulated a vasculature design problem as a topology optimisation problem with diffusion criterion. Solid isotropic material with penalisation (SIMP) method was employed to optimise two-dimensional model, which consisted of a fluid phase that had a high diffusivity and a solid phase that had a low diffusivity. A range of optimised vascular designs had been thereafter obtained by using different fluid and solid diffusivity values. It was found that with a very low solid diffusivity, the optimised fluid phases resemble natural vascular systems and exhibit certain degree of fractality. Increasing solid diffusivity or increasing surface flux at the modelling boundary reduced the resultant fractality. The link between optimality and fractality was found to be case-specific, generally associated with low diffusivity, high volumetric force, and low surface flux.

Keywords: Diffusion optimisation, Fractal, Artificial Vasculature