# Re-design of Tesla valves using topology optimization

**Sen Lin[1], James K. Guest[1], Yongbo Deng[2], Zhenyu Liu[2]**
*[1]Department of Civil Engineering, Johns Hopkins University, Baltimore, MD 21218, USA*
*[2]Changchun Institute of Optics Fine Mechanics and Physics, Chinese Academy of Sciences, Changchun, Jilin 130033, China*

## Abstract

Tesla valves are passive valves that provide low resistance to fluid flow in one direction while inhibiting flow in the reverse direction. This diode-like behavior is achieved by utilizing fluid forces instead of any moving mechanical parts, thus suitable for applications in micro-machines, particle-laden flow, etc., where part failure and/or clogging are prone to occur. This paper uses topology optimization to re-design and improve upon the original intuition-driven designs of Nicola Tesla.

The Tesla valve topology optimization problem is posed and solved using the material distribution approach with inverse diodicity as objective function and fluid volume fraction as the constraint. Incompressible fluids with Reynolds numbers up to 100 are considered. As in typical fluid topology optimization, the discrete no-slip boundary condition is regularized by modeling the solid phase as a porous medium with small permeability. However, unlike fluid topology optimization for minimum dissipated power, solutions are found to be mesh dependent, with smaller features developing with finer meshes. This non-convergent property is also problematic from a manufacturing point of view, as small features may not be achievable. These issues are circumvented in this work by imposing a minimum scale on designed features via projection methods. Several domain examples are considered and optimized designs are shown to be near discrete, manufacturable, and offer improved performance over the original Tesla valve, as well as other recently published designs.