Calibrating rate dependent shear properties of an artificial brain tissue stimulant using a reverse engineering approach

Cong Chen, Xin Jin, Feng Zhu and King H. Yang

Wayne State University

Abstract

Silicone gel is an ultra-soft medium which has similar mechanical properties as brain tissues and has been used as the brain surrogate in many biomechanical studies. This paper presented a reverse engineering based methodology to identify the shear properties of silicone gel at a wide range of strain rates. The basic idea is to combine the numerical modeling with the genetic optimization algorithm. Shear tests were conducted on 12 x 12 x 8 mm sylgard (product no. 527, Dow Corning, Midland, Michigan) specimens at six different strain rates (0.01/s, 0.1/s, 1/s, 10/s, 100/s, and 1000/s). Force-deflection curves obtained from the experiments were used to minimize an objective function, which is defined as the discrepancy between the test data and model predictions at loading rates of 0.01, 1, 10, and 100 per second. Genetic algorithm was employed to search the optimal parameters within the design space. At the end of optimization, material parameters of Ogden model were obtained to best fit the calculated responses to experimental measurements in a least-square sense. The optimized parameters were then validated against experimental data at strain rates of 0.1/s and 100/s, which were not used for optimizing material parameters. Experimental results indicated that the material property of silicone gel was non-linear and rate dependent. Ogden model was chosen to simulate the gel and the material parameters were optimized to describe the shear responses at a wide range of strain rates. This new approach can be used to identify the material parameters of soft biological tissues or engineering materials with a relatively small number of samples.