Abstract

Ionic polymer metal composites (IPMC) are a new class of smart materials that have attractive characteristics such as muscle like softness, low voltage and power consumption, and good performance in aqueous environments. Therefore, there is a significant motivation for research on design and development of IPMC based biomimetic propulsion systems for underwater vehicles. In aerospace, underwater vehicles finds application for forensic studies of spaceship wrecks, missile fragments and any airplane accidents in sea and ocean terrains. Such vehicles can also survey moons and planets that house water oceans. Among biomimetic swimming systems, fish inspired swimming has gained interest since fish like swimming provides high maneuverability, high cruising speed, noiseless propulsion and efficient stabilization compared to conventional propulsion systems. In this work, the paired pectoral fin based oscillatory propulsion using IPMC for aquatic propulsor applications is studied. Dynamic characteristics of IPMC fin are analyzed using numerical simulations and optimization is used to improve the fin design. A complex hydrodynamic function is used to describe the behavior of an active IPMC fin actuator in water. The structural model of the IPMC fin is obtained by modifying the classical dynamic equation for a slender beam to account for the electromechanical dynamics of the IPMC beam in water. A quasi-steady blade element model that accounts for unsteady phenomena such as added mass effects, dynamic stall, and the cumulative Wagner effect is used to estimate the hydrodynamic performance of the flapping fin. It is shown that the use of optimization methods can lead to significant improvement in performance of the IPMC fin. Further, three fish species with high performance flapping pectoral fin locomotion are chosen and performance analysis of each fin design is conducted to

discover the better configurations for engineering applications. Dynamic characteristics of IPMC actuated flapping fins having the same size as the actual fins of three different fish species, *Gomphosus varius*, *Scarus frenatus* and *Sthethojulis trilineata*, are also analyzed. Finally, a comparative study is performed to analyze the performance of the three different biomimetic IPMC flapping pectoral fins.