Modeling and Adaptive Control of Microbial Fuel Cells

Abstract

Microbial fuel cells (MFCs) are considered a promising technology to extract energy from organic compounds and turn them into electricity. Production of electrical energy from wastewater using MFC can offer an economical solution to the problem of environment pollution and energy crisis in near future. MFCs are still a challenging technology at laboratory level and yet to be commercialized significantly. Mathematical models are required to obtain a relationship between parameters, inputs, outputs and system behaviour. Few mathematical models of MFCs are developed and verified under certain assumptions and conditions. To obtain an optimal performance of the MFCs, its operation must be under controlled conditions. MFCs need a control system for balance across fuel supply, mass, charge, and electrical load. Control-oriented models help in developing model based control strategies. The enhancement of the advanced control techniques such as input/output linearization, feedback linearization, model predictive control, optimal control, PID control, gain scheduling control etc. will apply to the MFCs. Nonlinear control schemes can handle system uncertainties and on-line parameter estimation and provide system robustness. Backstepping is a nonlinear control method whose key advantage is its ability to handle systems with two or more relative degrees. In this control scheme, state variables are considered as 'virtual controls' and intermediate control laws are developed for the respective state variables. An adaptive action provides the on-line estimation of unknown parameters through adaptive control laws and adjusts parameter values during the operation. The control objective is to develop a backstepping control scheme to achieve an optimal performance of the MFC while controlling substrate concentration at a particular set point.