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Design of Electrical Power Generation from Soil Cell

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Abstract: Microbial fuel cell is a kind of promising new source of green energy. Because of its complicated reaction mechanism and its inherent characteristics of time-varying, uncertainty, strong-coupling and nonlinearity, there are complex control challenges in modelling and control of microbial fuel cells. This paper studies on performance improvement of microbial fuel cells by the approach of model predictive control. A numerical simulation platform for microbial fuel cell is established, and a traditional model predictive controller is designed for MFC first; then model predictive controllers which use Laguerre function and exponential data weighting are designed subsequently to compare with the traditional model predictive controller. Simulation results show that the proposed improved model predictive controller modified by exponential data weighting can give the system both good steady-state behaviour and satisfactory dynamic property.

Keywords: Microbial fuel cell; Model predictive control; Exponential data weighting; Constant voltage transmission

I. INTRODUCTION

This Energy resource is an important material basis for the survival and development of human society [1, 2]. Conventional fossil fuels have been largely used and are gradually dying up. Meanwhile, massive environmental pollution has been brought on by productive gaseous and solid waste when conventional fossil fuels are burned in the process of power generation [3]. Therefore, there is an increasing need for renewable energy in our society, pollution-free energy sources with high energy conversion efficiency and null pollutant emissions are attempted to explore and exploit [4]. A Microbial Fuel Cell (MFC) is a bio-electrochemical system that drives a current by mimicking bacterial interactions found in nature. Microbial fuel cell is considered to be a promising sustainable website. technology to meet increasing energy needs. Microbial fuel cells have many potential advantages over traditional methods of generating electricity [5]. The great advantage of the microbial fuel cell is the direct conversion of organic waste into electricity. It enables high conversion efficiency and efficient operation at ambient. Microbial fuel cell has current and potential uses in wastewater treatment, desalination, hydrogen production, remote sensing, pollution remediation, and as a remote power source [6]. The applications of MFCs will help to reduce the use of fossil fuels and allow for energy gain from wastes, and they will help to bring the world to become a sustainable and more eco-friendly place [7]. MFCs are complex biological electrochemical reaction systems. Many factors such as environmental temperature, substrate concentration, biological environment and load disturbance will have a significant impact on its performance [8, 9]. Therefore, before put it into a large number of applications, some problems of microbial fuel cell such stability, reliability, electricity production efficiency must be solved first. The complexity of a microbial fuel cell makes it difficult to improve its performance. So far, almost all researches on microbial fuel cells are still focused on the structure or material option of the microbial fuel cell itself, to realize performance optimization by controlling is rarely considered. Advanced control technology is an alternative solution to optimize the performance of the microbial fuel cell. Model Predictive Control (MPC) is an optimization strategy for the control of constrained dynamic systems. It is an effective method to solve complex industrial process control [10, 11]. Model predictive controller is considered to control the MFC to maintain a constant output voltage in our work. This paper is organized as follows. The mathematical model for a typical microbial fuel cell is described in Section 2. Section 3 presents a brief description of designing three kinds of model predictive controllers for MFC. Simulation results are presented in section 4 to confirm the effectiveness and the applicability of the proposed method. Finally, our work of this paper is summarized in the last section.

II. LITERATURE SURVEY

In A Self-Powering Wireless Environment Monitoring System Using Soil Energy, *IEEE SENSORS JOURNAL, VOL. 15, NO. 7, JULY 2015*Design of a wireless environment monitoring system with the help of renewable soil energy. The microbial fuel cells developed for converting the chemical energy to electrical energy with the help of D-size cell. The

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wireless sensors are used to monitor the environmental conditions using wireless temperature and air moisture sensor system. The system includes a DC-DC converter, low power microcontroller, air humidity sensor, custom capacitive humidity sensor readout IC, and a Bluetooth low-energy transceiver with embedded temperature sensor. The data from the temperature sensor is sent to the microcontroller for data processing. The microcontroller periodically wakes up the sensor and wireless transmitter only at a short-time interval. A synchronous loop is added to ensure that the microcontroller can capture the correct sensor data.

Design of a multifunctional wireless sensor for in-situ monitoring of debris flows, IEEE Trans. Instrum. Meas., vol. 59, no. 11, pp. 2958–2967, Nov. 2010.Debris flows carrying saturated solid materials in water flowing downslopes often cause severe damage to the lives and properties in their path. Close monitoring and early warning are imperative to save lives and reduce damage. Current debris-flow-monitoring systems usually install sensor equipment along the riverbanks and mountain slopes to detect debris flows and track their data. Unfortunately, most of this equipment indirectly collects data only from a distance. So far, there is no way to understand what is happening inside a debris flow columns.

III. MODEL OF A MICROBIAL FUEL CELL

All Electricity generation in MFCs has been modelled by a few researchers. Picioreanu et al described the integration of IWA's Anaerobic Digestion Model (ADM1) within a computational model of microbial fuel cells [12]. Pinto et al presented a two-population model describing the competition of anodophilic and methanogenic microbial populations for a common substrate in a microbial fuel cell [13]. Picioreanu et al described and evaluated a computational model for microbial fuel cells based on redox mediators with several populations of suspended and attached biofilm microorganisms, and multiple dissolved chemical species [14]. Kato et al developed a one-dimensional, multi-species dynamic model for the biofilm of the microbial fuel cell [15]. These models are concentrated on biocatalytic activities. Complexity of the system and involvement of many model parameters causes poor accuracies in the suggested model. Zeng and his research team applied themselves to develop a MFC model similar to that for chemical fuel cells. By integrating biochemical reactions, Butler–Volmer expressions and mass/charge balances, a MFC model based on a two-chamber configuration is developed to simulates both steady and dynamic behavior of a MFC, including voltage, power density, fuel concentration [16]. This is a comprehensive model for a two-chamber microbial fuel cell. So, the simulation platform in this paper is established mainly based on Zeng's MFC model, and some modelling methods described in some other references are used for making some modification. Concentration of dissolved oxygen in the cathode compartment; ηa is the anodic over potential; ηc is the over potential at the cathode; α is the charge transfer coefficient of the anodic reaction; β is the charge transfer coefficient of the cathodic reaction; 0 1 k is the rate constant of the anode reaction at standard conditions (maximum specific growth rate); 0 2 k is the rate constant of the cathode reaction under standard conditions; KAC is the half velocity rate constant for acetate; KO2 is the half velocity rate constant for dissolved oxygen. Water concentration is assumed constant.

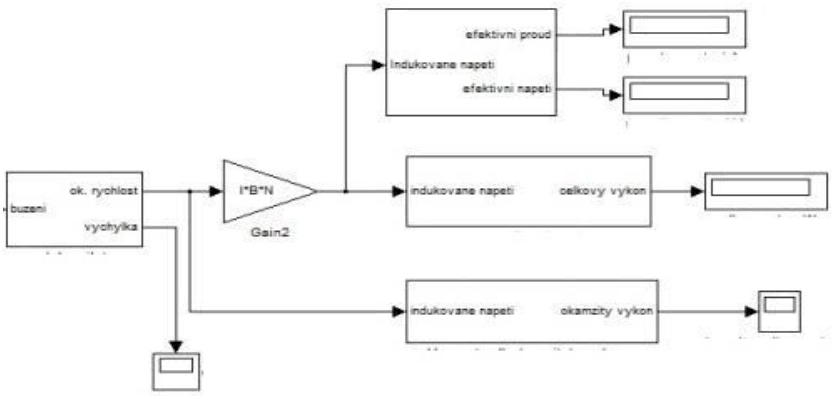

Fig 1 .Generator simulation model

When the plant is running under the traditional MPC, the predictive horizon is 20, the control horizon is 2, and the output weight is a unit matrix. When the plant is running under the MPC with laguerre functions substituting the control variables (LMPC) and under the exponentially weighted corrected MPC (EMPC), the two core factors are a is 0.3 and N is 4, the predictive horizon is 48, the weighting =T Q C C , and RL=0.3I. What's more, α is chosen as 1.5 in the MPC with exponentially weighted corrected control strategy. The sampling time of the three control strategies is 1s. Soil is the most spatially complex stratum on Earth, containing minerals and many organisms, such as bacteria, fungi, algae, protozoa, nematodes, and earthworms. The organic matter in subsurface environments and aquatic sediments represents a large potential source of energy. Some bacteria in the soil are known to generate electricity (exo-electrogens) without the provision of an exogenous media [6].The soil energy can be an alternative energy source to remedy the environment and energy endeavours. Through biochemical reactions from the activities of the microorganisms, the energy in the soil can be released as electricity and heat. Recently, the chemical-to-electricity conversion processes from bacteria are utilized to establish microbial fuel cells .The electrical properties of the soil are affected by the type of soil, density, operating frequency, water content, and soluble salts and minerals. The equivalent circuit provides insights for optimizing the MFC design and enhancing the output power. However, MPC with exponential data weighting can make the MFC system present faster response, smaller overshoot and higher steady-state accuracy than general MPC, and it also can give more control effect than MPC with Laguerre functions. By analysing, we can also find some fact results. Both substrate concentration and environmental temperature are important factors that influence the operation performance of a microbial fuel cell. By real-time adjustment of the feed flow rate in cathode, the output voltage of the microbial fuel cell can be controlled at the given value even though it suffers from perturbations. Whether it is disturbance in substrate concentration or environmental temperature, the model predictive controller can resist the disturbance influence well. Compared with the references which come down to control of MFC , this paper presents the only scheme concerned about the realization of constant voltage output of the microbial fuel cell. With comparison between the results obtained under the control scheme presents in this paper and the results shown in reference , it can be seen that the control scheme presented The aim of the simulation is to build a model of the electroc generator and its tuning to obtaining the maximum total power generated by meeting the condition The simulation model is built in Matlab Simulink in the form of block notifications equations of mathematical and physical model and their interconnection. The main entrance to the generator model there are vibrations that have a sinusoidal waveform a the output is the total power of the generator. As an evaluation of the correctness and functionality of the model Serves secondary outputs showing instantaneous deflection, instantaneous total power, and effective current and voltage values on the load.

IV. CONCLUSION

Microbial fuel cells have complicated reaction mechanism, and they need good power control systems to keep them working in some required running states. By using right MPC controller, the microbial fuel cell can not only have fast response characteristic, but also have good steady-state behavior and strong robustness. The suitable model predictive control scheme can get satisfactory results in tracking a given voltage and make the microbial fuel cell output a required constant voltage.

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