UNIVERSITI PUTRA MALAYSIA

DESIGN OF PROFILE CONTROLLER FOR BIOCHEMICAL REACTOR

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FK 2010 44

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

September 2010

DEDICATIONS

"To My ever-encouraging parents for their love and supports"

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

DESIGN OF PROFILE CONTROLLER FOR BIOCHEMICAL REACTOR

By

ARASH ASADZADEH GHARAHVARAN

September 2010

Chair: Professor Sudhanshu Shekhar Jamuar, PhD

Faculty: Engineering

The biotechnology industry is growing sharply due to progress in understanding of complex biological systems and high demand for chemical and biologically manufactured products. Bioreactors are used for the production of materials like ethanol, or extraction of enzymes from microorganisms, animal or plant cells.

In order to maximize the productivity, the bioreactor needs optimal conditions for process parameters such as pH, temperature, and dissolved oxygen (DO). The goal of achieving high performance controller is the answer to these demands. There are many types of process controllers like the ON/OFF controller, PID controller, and controller based on an artificial intelligence. Neural network and PID controllers have been used together to learning system features, and to reduce the residual error as well as to replace currently PID controllers in the proposed design.

This research focuses on designing a profile controller for pH, DO, and temperature that affects production of ethanol. The temperature is controlled by the following a

cooling agent, and the pH is controlled by adding the appropriate amount of base or acid, while the dissolved oxygen is controlled by changing the speed of the stirrer. The inputs to the bioreactor are cooling agent (F_{ag}), flow of base (F_b), and stirring speed of the liquid (N_{stir}). The parameters that need to follow a given profile are temperature, pH, and dissolved oxygen.

This thesis presents the use of Inverse Neural Networks (INN) for temperature control of a biochemical reactor and its effect on ethanol production. The process model is derived indicating the relationship between temperature, pH and dissolve oxygen. Using the fundamental model obtained data sets; an inverse neural network has been trained by using the back-propagation learning algorithm.

Two types of temperature profile are used to compare the performance of the controllers. The controllers have been simulated to have a quantitative comparison with two types of the controllers and show the effectiveness of the INN controller versus the conventional PID controller. The results obtained by the neural network based INN controller and by PID controller are presented and compared. There is an improvement in performance of INN controller in ISE over PID controller.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

REKABENTUK BAGI PROFIL PENGAWALAN UNTUK REAKTOR BIOKIMIA

Oleh

ARASH ASADZADEH GHARAHVARAN

September 2010

Pengerusi : Professor Sudhanshu Shekhar Jamuar, PhD

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Industri bioteknologi sedang pesat membangun sejajar dengan kemajuan dalam pemahaman kompleks sistem biologi dan permintaan tinggi dalam pengilangan produk kimia dan biologi. Bioreaktor digunakan bagi pengeluaran bahan-bahan seperti ethanol atau ekstrak enzim-enzim daripada mikroorganisma haiwan, sel-sel haiwan, sel-sel tumbuhan, dan sebagainya.

Bagi memaksimumkan produktiviti, bioreaktor memerlukan keadaan yang optimum bagi proses parameter seperti pH, suhu dan oksigen terlarut (DO). Matlmat pencapaian prestasi dalam sistem pengawal adalah jawapan kepada proses-proses ini. Terdapat banyak jenis proses-proses pengawalan seperti pengawal 'ON/OFF', pengawal PID, dan pengawal yang berdasarkan kepada kecerdasan buatan. Jaringan saraf dan pengawal PID telah digunakan bersama-sama bagi membangunkan kebolehkawalan, ciri-ciri sistem pembelajaran dan untuk mengurangkan tahap kesilapan serta menggantikan satu pengawal PID terkini dalam cadangan rekabentuk.

Penyelidikan ini tertumpu di dalam mereka satu pengawal bagi pH, DO dan suhu yang menjejaskan penghasilan etanol. Suhu ini dikawal dengan pengaliran satu agen penyejukan dan pH adalah dikawal dengan menambahkan jumlah asas atau asid, manakala oksigen terlarut adalah dikawal dengan menukar kelajuan mengacau. Input-input bagi bioreaktor adalah agen penyejukan (F_{ag}), aliran asas (F_b), dan kelajuan mengacau cecair (N_{stir}). Parameter-parameter yang diperlukan untuk mengikuti profil yang telah diberikan adalah suhu, pH dan oksigen terlarut.

Tesis ini membentangkan mengenai penggunaan 'Inverse Neural Networks' (INN) bagi kawalan suhu reactor biokimia dan kesannya kepada penghasilan etanol. Proses ini menunjukkan hubungan antara suhu, pH dan oksigen terlarut. Dengan menggunakan model asas yang merangkumi set-set data, jaringan saraf sonsang yang terlatih dengan menggunakan kaedah algoritma.

Dua jenis suhu profil yang digunakan bagi membandingkan prestasi alat-alat pengawal. Alat-alat pengawal telah disimulasikan bagi membuat suatu perbandingan antara dua jenis alat pengawal dan menunjukkan kecekapan alat pengawal INN dengan alat pengawal PID konvensional. Keputusannya adalah dengan memperoleh jaringan saraf alat pengawal INN dan alat pengawal PID yang telah dibentang dan dibandingkan. Terdapat satu peningkatan di dalam alat pengawal INN di dalam penetapan jangka masa alat pengawal PID.

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to Professor Dr. Sudhanshu Shekhar Jamuar, the chairperson of my supervisory committee, for his invaluable guidance, patience, understanding, encouragement, and supervision throughout the study until the completion of this thesis.

I am also grateful to other members of the supervisory committee, Dr. Samsul, and Dr. Fakhrul for their comments. I would like to express my special thanks to my truly friends, Dr. Mahmood Akhavan Mahdavi, and Mr. Esmaeel Atashpaz for their help and advises at all times, KEE department staff and numerous people who have walked with me along this way.

My deep love to my parents, Hosein Asadzadeh and Bibi Mansureh Hoseini Fatemi, for their unconditional supports, assistance, encouragement, and patience throughout this long process of study.

Once again, thank you to everyone who has aid me in the completion of this thesis. I am humbly grateful for your care.

Sincerely

Arash Assadzadeh

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for other degree at Universiti Putra Malaysia or at any other institution.

ARASH ASADZADEH GHARAHVARAN

Date: 20/9/2010

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