FUZZY CONTROL OF CONTINUOUS STIRRED TANK REACTOR

By

HASMAH BINTI MANSOR

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

March 2006

DEDICATION

To my husband, Muhammad Helmy, my son Muhammad Fareezy Fahmy and my daughter Nur Farisya Alyssa…

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

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March 2006

Chairman: Samsul Bahari Mohd. Noor, PhD

Faculty: Engineering

Continuous Stirred Tank Reactor (CSTR) involves complex reactions, highly non-linear and very hard to control by conventional methods. Fuzzy controller is introduced in this research to control the CSTR. A powerful design and simulation tool which is MATLAB and SIMULINK has been used for evaluation and test.

In this research, the process considered is the decomposition of hydrogen peroxide (H_2O_2) using Fe^{3+} as the catalyst. The product is water (H_20) and dissipated oxygen (O_2). The main task is to maintain the temperature and concentration in the CSTR around the working point, in spite of disturbances by manipulating the flowrate of inlet or outlet stream and coolant temperature.

Two fuzzy controllers have been designed and tested based on Mamdani and Sugeno inference mechanisms. Performance comparisons have been made; first between the two controllers and second between the best fuzzy controller and previous researches on the similar topic but using different techniques. The overall performance of both

Mamdani and Sugeno based fuzzy controller are excellent. The tests results showed that Sugeno and Mamdani based fuzzy controllers have no significant difference in performances due to slow process occurred in the CSTR. However, Sugeno based fuzzy controller slightly improves the response time of Mamdani based fuzzy controller by 20%. Steady state error is also reduced to less than 1%. Furthermore, the simulation time is also reduced.

Fuzzy control provides a simple technique but yet the achievements are comparable to other more complicated and time consuming techniques. Various tests have been conducted throughout this research to show the robustness of both fuzzy controllers.

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

KAWALAN SAMAR UNTUK TANGKI REAKTOR PENGACAU BERTERUSAN @ CONTINUOUS STIRRED TANK REACTOR

Oleh

HASMAH MANSOR

Mac 2006

Pengerusi: **Samsul Bahari Mohd. Noor, PhD**

Fakulti: **Kejuruteraan**

Tangki reactor pengacau berterusan atau lebih dikenali sebagai Continuous Stirred Tank Reactor (CSTR) melibatkan reaksi yang rumit, sangat tidak berkadaran dan sangat sukar dikawal melalui kaedah lama. Alat kawalan samar diperkenalkan didalam kajian ini untuk mengawal CSTR. Alat terbaik untuk mereka dan simulasi iaitu Matlab dan SIMULINK telah digunakan untuk ujian dan analisa.

Di dalam kajian ini, proses yang diambil kira ialah penguraian hidrogen peroxida (H_2O_2) menggunakan Fe3+ sebagai pemangkin. Hasilnya ialah air (H_2O) dah oksigen (O_2) yang dibebaskan. Tugas utama ialah untuk mengekalkan suhu dan kepekatan di dalam CSTR di dalam lingkungan yang ditetapkan walaupun adanya gangguan luar dengan memanipulasi arus larutan masuk atau keluar dan juga suhu alat penyejuk.

Dua alat kawalan samar telah dihasilkan dan diuji berdasarkan mekanisma inference Mamdani dan Sugeno. Perbandingan telah dibuat; pertama di antara kedua-dua alat kawalan samar dan kedua di antara pencapaian terbaik alat kawalan samar tersebut

dengan pencapaian yang diperolehi daripada kajian-kajian sebelum ini tetapi menggunakan teknik yang berlainan. Secara keseluruhannya pencapaian kedua-dua alat kawalan samar Mamdani dan Sugeno adalah cemerlang. Hasil ujian menunjukkan alat kawalan samar Sugeno dan Mamdani tidak mempunyai perbezaan ketara dari segi masa tindakbalas kerana process yang berlaku di dalam CSTR adalah sangat perlahan. Walau bagaimanapun, alat kawalan samar Sugeno memperbaiki masa tindak balas alat kawalan samar Mamdani sebanyak 20%. Ralat tetap juga berkurangan kepada kurang dari 1%. Tambahan pula, masa untuk simulasi juga berkurangan.

Alat kawalan samar menawarkan satu kaedah yang mudah tetapi hasil yang diperolehi setara dengan hasil yang diperolehi dengan menggunakan kaedah lain yang lebih rumit dan mengambil masa yang panjang. Pelbagai ujikaji telah dibuat sepanjang penyelidikan ini bagi menguji ketahanan maksima kedua-dua alat kawalan samar.

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Last but not least, my greatest gratitude to all my family and friends for their encouragement and understanding.

Wassalam…

I certify that an Examination Committee has met on 21st March 2006 to conduct the final examination of Hasmah binti Mansor of her Master of Science thesis entitled "Fuzzy Control of Continuous Stirred Tank Reactor" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Reguations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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HASMAH MANSOR

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