

SIMULATION OF ADAPTIVE CONTROL OF CONTINUOUS STIRRED TANK REACTOR

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Abstract

Chemical reactors are often characterized by highly nonlinear behaviour. In such cases, the use of conventional control strategies where controllers have fixed parameters can result in poor performance. Knowledge about the static and dynamic properties is a necessary condition for the design of a controller. Unfortunately, measurements on the real system are not always feasible. The only way as to how to obtain static and dynamic behaviour of these systems is through the use of simulations, i.e. experiments on their mathematical model. Steady-state analysis shows the behaviour of the system in the steady state, which can help with the choice of the optimal working point, i.e. the appropriate combination of the input variables, which results in maximal production with minimal cost. On the other hand, the dynamic analysis results in the suitable control strategy. The adaptive approach in this work uses the recursive identification and the polynomial synthesis with the pole-placement method.

(Received in November 2008, accepted in March 2009. This paper was with the authors 1 month for 1 revision.)

Key Words: Adaptive Control, Polynomial Approach, Pole-Placement Method, Continuous Stirred Tank Reactor

1. INTRODUCTION

Continuous Stirred-Tank Reactors (CSTRs) make up the majority of equipments in the chemical and biochemical industry [1]. Control of such processes is very frequent – e.g. [2], [3] and [4]. This paper is focused on the simulation studies of a CSTR with the Van der Vusse reaction inside [5].

Simulations have big advantages nowadays with the increasing computation power and speed of the computers followed by the decreasing costs. The simulation process usually starts with the modelling of the system. The result of the modelling is the mathematical model of the system, which describes the most important variables and relations between them [6]. The mathematical model of the examined CSTR is described by the set of four nonlinear ordinary differential equations (ODE). The simulation of the steady-state and dynamic behaviour was performed on this mathematical model. The simple iteration method was used for the steady-state analysis [7]. Similarly, the dynamic analysis was performed by Runge-Kutta's standard method [8]. Results of the steady-state and dynamic analyses are optimal working point and the choice of the External Linear Model (ELM) for the control part.

The adaptive approach [10] used in the control part is based on the choice of External Linear Model (ELM) of the originally nonlinear process, parameters of which are estimated recursively during the control according to the actual state of the system [11]. Although the identification runs in discrete time, the ELM here uses delta models parameters, of which small sampling period are close to the continuous ones [12]. Various types of identifications can be used in the estimation part. The majority of methods are based on the Recursive Least Squares (RLS) method. This method is simple, easily programmable and connected with its

system, which results in inappropriate control responses and overshoots. However, the control response after the second and higher step change is usually much better.

This disadvantage could be reduced with the use of exponential function for the reference signal instead of the ordinary step function. The optional tuning parameter in the pole-placement method with spectral factorization is position of the pole (root) α_i . The increasing value of this parameter results in quicker responses but overshoots of the output variable, as it is shown in the practical part. Proposed adaptive controllers have good results of the control and fulfilled basic control requirements such as the stability, the reference signal tracking and disturbance attenuation.

The future work will be focused on the application of these simulation and control studies on the real CSTR as a verification of the simulation results credibility.

5. ACKNOWLEDGEMENTS

This work was supported by the Ministry of Education of the Czech Rep. under grant No. MSM 7088352101.

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