Identification of a Distillation Column for PLC Control Purposes

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1 Introduction

In a world where economic and environmental issues become more and more important, efficient control systems have become indispensable. When dealing with complex processes, Model Predictive Control (MPC) is one of the possible control strategies[1]. In practice, current linear and non-linear MPC algorithms require powerful computers. However, since Programmable Logic Controllers (PLCs) with less computational power are used a lot in industry for control, it might be interesting to explore the possibilities and limitations of these devices for MPC. For this purpose, a 6 m high pilot scale binary distillation column, is selected as an industrial example.

2 Goal

The column is currently controlled by PI controllers, but the goal is to upgrade the control system with a linear MPC running on a PLC. However, before a model based controller can be used on a PLC, an accurate (but simple) process model has to be constructed. Therefore linear parametric MIMO black-box models (e.g., ARX, ARMAX, and output error) are adopted.

3 Experimental set-up

In this set-up, four variables can be manipulated: the reboiler duty Qr, the feed rate Fv, the duty of the feed heater Qv and the distillate flow rate Fd. Measurements are available for the distillate flow rate Fd , the feed flow rate Fv and nine temperatures, i.e., the temperature at the top of the column Tt, the temperatures in the center of every packing section ($Ts1$, $Ts2$ and $Ts3$, respectively), the temperature between section 1 and 2 $Tv1$, the ambient temperature $Tamb$, the temperature in the reboiler of the column Tb, and the temperatures of the feed before and after heating ($Tv0$ and Tv, respectively).

4 Model identification procedure

A parametric model is fitted following the Box-Jenkins modelling procedure using the Matlab System Identification Toolbox [2, 3]. An experiment with PRBN input signals is performed for 20000 seconds. From these recorded signals, 5 inputs (Qr, Fv, Qv, Fd and $Tamb$) and 5 outputs ($Ts1$, $Ts2$, $Ts3$, Tt and Tb) are selected to create a model. Two datasets are prepared: one with sampling rate of 5 seconds and an other with sampling rate of 60 seconds. Both sets are split up in an identification and validation part. MIMO ARX, ARMAX and OE models are fitted and validated. The AIC criterium is adopted to select the correct model order. Additional model reduction is performed with the help of Hankel Singular Values.

5 Results

Only ARX and ARMAX models predicts the output accurately, but the best performing models are ARMAX models. After model reduction and conversion, these models result in a 6th order state space model for both datasets. The authors believe that these models (despite their low complexity) will predict the output accurately enough to be employed in an MPC algorithm which can be implemented on a PLC.

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