Identification and control of a binairy distillation column in view of PLC based control

Bart Huyck, Jos De Brabanter
KaHo Sint Lieven - Department Industrieel Ingenieur
Email: bart.huyck@kahosl.be jos.debrabanter@kahosl.be

Filip Logist, Jan Van Impe
K.U.Leuven - Department of Chemical Engineering (CIT)
Email: filip.logist@cit.kuleuven.be jan.vanimpe@cit.kuleuven.be

Bart De Moor
K.U.Leuven - Department of Electrical Engineering (ESAT - SCD)
Email: bart.demoor@esat.kuleuven.be

1 Introduction

In a world where economic and environmental issues have increasing importance, 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 are most often implemented on powerful computers. However, since Programmable Logic Controllers (PLCs) with less computational power are used a lot in industry, it is 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 test example with multiple inputs and outputs.

2 Experimental set-up

In the distillation set-up, four variables can be manipulated (MV): the reboiler duty, the duty of the feed heater and the reflux and feed flow rate. The controlled variables (CV) of the system are the temperatures in the reboiler and at the top of the column. Only these variables are employed for the control of the column as they are strongly related to the quality of the final products. Other measurements are available, but are currently omitted for control.

3 Results

To create a model of the distillation column, system identification is performed [2]. A Pseudo Random Binary excitation signal is applied simultanious to the four MVs. From former experiments [4], it is known that the dynamics of the system are faster at the top of the column. Therefore, the signal is slightly faster at the top. As distillation columns consist of low order systems, the selected models to be fitted, are first and second order continuous-time transfer functions with time delay. For both the reboiler and bottom temperature, a MISO model is identified and combined into one MIMO model. Model validation on a different dataset demonstrates that the MISO model describing the reboiler temperature captures the dynamics of the system excellently, while the MISO model for the top temperature has difficulties following the fast temperature variations. Nevertheless the global MIMO model describes all main trends well and, hence, it is implemented in an MPC controller taken from the Matlab Model Predictive Control Toolbox [3]. As a first step towards control on PLCs, this MPC controller is tested while running on a PC. Simulation tests, as well as experiments on the pilot scale set-up have proven that the controller accurately deals with desired setpoint changes without violating constraints.

4 Conclusion

A linear model has been created for a binairy disllation column. The model has been validated and employed in an MPC. This controller has proven to be successful in simulation and on the real set-up. Further research will now focus on the translation of the current model predictive control approaches to low level industry standard hardware.

5 Acknowledgements

Work supported in part by Projects OT/09/025/TBA, EF/05/006 (Center-of-Excellence Optimization in Engineering) and IOF-SCORES4CHEM of the Research Council of the Katholieke Universiteit Leuven. J. Van Impe holds the chair Safety Engineering sponsored by the Belgian chemistry and life sciences federation essenscia.

References

[1] S. J. Qin and T. A. Badgwell. “A survey of industrial model predictive control technology,” Contr Eng Pract, 11:733764, 2003.

[2] L. Ljung. System Identification: Theory for the User, Second Edition. Prentice Hall, Upper Saddle River, New Jersey, 1999.

[3] A. Bemporad, M. Morari and N. L. Ricker. Model Predictive Control Toolbox 3 Users Guide. The MathWorks, Inc, Natick, 2009.

[4] F. Logist, B. Huyck, M. Fabre, M. Verwerft, B. Pluymers, J. De Brabanter, B. De Moor and J. Van Impe. ”‘Identification and control of a pilot scale binary distillation column.”’ Proc. ECC 09, p. 4659-4664, 2009.