Modelling and Analysis of Control Pairings of an Industrial Depropanizer Column

Martin Mojto[1], Radoslav Paulen[1], Karol Ľubušký[2], and Miroslav Fikar[1]

[1]*Faculty of Chemical and Food Technology, Slovak University of Technology in Bratislava, Bratislava, Slovakia*
[2]*Slovnaft, a.s., Bratislava, Slovakia*

February 15, 2019

Abstract

This work deals with modelling and control of a depropanizer distillation column of the Slovnaft refinery. The goal is to analyze different control structures and to suggest an effective one for the plant taking into account various disturbances.

We use the gPROMS ModelBuilder environment to design the mathematical model of the process. Here, we exploit the custom modelling capabilities provided by the Process Model Library (PML) such as automatic model generation of flash drums, column sections, etc. Separated mixture consists of nine components. Therefore, the advanced database of the Multiflash package for gPROMS is used to describe the physical properties of the mixture. This package also provides various analyses of the mixture under certain conditions and it is straightforward to include into the structure of the model.

In order to validate the obtained model, we simulate it for various operating conditions and compare the model response against historical plant data. Subsequently, we tune the parameters of the models such that the model matches the steady-state and transient behaviour of the plant. Here, we again use the available features of the gPROMS ModelBuilder, e.g., the ability to restore the steady-state conditions in-between multiple simulations. This saves the effort when correlating the plant data and the model response under different operating conditions. The comparison of the plant data and the simulation results show that the behaviour of the constructed model is similar to the behaviour of the real process.

Several control configurations (LV, LB, DV, LD and Ryskamp) are implemented within the gPROMS ModelBuilder to simulate the control of the plant. The controlled variables are the pressure, liquid levels, and temperatures. First, an analysis is perfomed based on Relative Gain Array (RGA) method, where we study various steady-state sets. The sets are gathered from the simulations of the model in the gPROMS ModelBuilder and represent typical operating conditions of the plant. The RGA analysis states that the pairing of variables is the most appropriate in the Ryskamp configuration. A further analysis is carried out to select the best control configuration based on the dynamic behaviour of the plant. Plant response is tested in simulation for set-point tracking and disturbance rejection for different control configurations. This analysis reveals that the control performance of LB, DV and LD configurations is not sufficient compared to Ryskamp and LV configurations.

The results show that the Ryskamp and the LV configurations are the most suitable for the control of the plant. While the Ryskamp configuration gives good control performance in both steady-state and dynamic analysis, the LV configuration is the simpler of the two and thus might be preferred as a trade-off between simplicity of the implementation and resulting control quality.

Acknowledgements

The authors gratefully acknowledge the contribution of the Slovak Research and Development Agency under the project APVV-15-0007, the Scientific Grant Agency of the Slovak Republic under the project 1/0004/17, and the European Commission under the project GuEst (grant agreement No. 790017).