"The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 257059. The 'Autoprofit' project (www.fp7-autoprofit.eu)"

WP 6 – BENCHMARKING AND INDUSTRIAL APPLICATION

WORK PACKAGE OBJECTIVES

Autoprofit's main idea is to detect when model/plant mismatch destroys MPC performance, and then correct that by updating the model and/or tuning. Simulation models are used to evaluate the tools and functions developed in a Matlab based benchmarking environment. This is a first step of validation.

As further validation the resulting prototype tools are applied to two industrial cases. By this it is expected to learn:

- How well do they work in practice
- If they don't work, find out why
- What needs to be added to improve usability

SIMULATION MODELS

Distillation column

Control and optimization objectives

Top composition above constraint – But not too far
Bottom composition less important

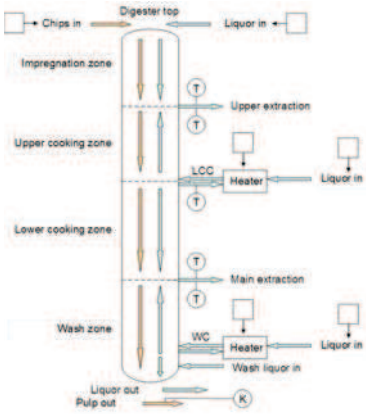
Control solution: MPC with …

Controlled variables (CV): Top composition, yt
Bottom composition yb
Manipulated variables (MV): Liquid flow, L
Vapor flow, V

Main scenarios to study

Change of plant gain directionality by use of a rotation matrix
Increased disturbance level in feed composition and flow rate

Pulp digester



Control objectives

· Kappa number (remaining lignin) at setpoint or below constraint
· Temperatures within constraints

Control solution: MPC with …

Controlled variable (CV):
· Kappa number
Manipulated variables (MV):
· 3 liquor flows,
· 2 temperature setpoints
Feedforward variable (FF):
· Chip feed rate
Process variables for state estimation (PV):
· 5 temperatures

Main scenarios to study

Hardwood or softwood pulp
Operating at different Kappa

INDUSTRIAL CASES

FT Depropanizer in synthetic fuel catalytic cracker plant

A 56 tray distillation column that separates C3 and lighter components (side draw) from C4 and heavier components (bottom)

SCC plant

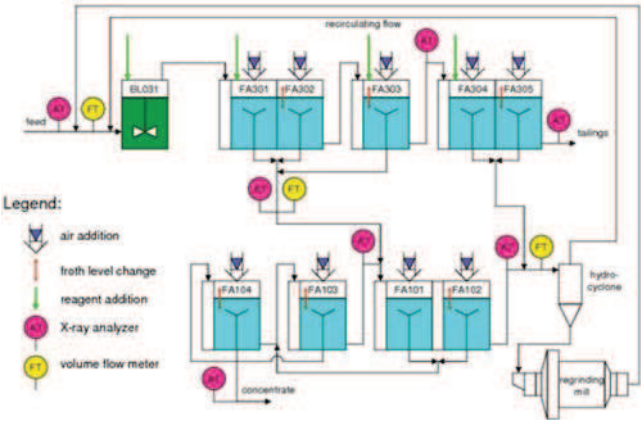
MPC with …

11 CV: C4 content in side draw; Feed drum level and rate-of-change; Column pressure; Bottom temperature; Reboil flow; 5 control valve positions
4 MV: Feed; Ratio between side draw and feed; Delta pressure; Feed to C3 header sharing the same feed drum
3 FF: Feed drum pressure and its control valve position; Another feed sharing the same feed drum

Objectives:

Maximize C3 production (side draw flow) while maintaining its C4 impurity within specification. Prevent flooding and flaring. Use buffer capacities in feed drum and bottom to reduce feed variations.

Flotation process in a zinc ore concentration plant



Flotation tanks

MPC with …

2 CV: Zn concentration in product and tailings
3 MV: Two air flows, reagent addition
1 FF: Ore feed Zn concentration (varies 3-11%)
3 PV: Two Zn concentrations, recirculating flow

Objective: Maintain the CVs at their setpoints, and adjust the setpoints for optimal operation

WORK PACKAGE PARTICIPANTS

All Autoprofit partners are taking active part in this work package

Coordinator Contact: Prof. dr. ir. Paul Van den Hof, Delft University of Technology, P.M.J.vandenhof@tue.nl

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WP 6 –APPLICATION TO AN INDUSTRIAL FT-DEPROPANISER

INTRODUCTION

The Experimental Validation Campaign at SASOL

The purpose of the industrial validation campaign was to determine whether the AUTOPROFIT work package developments may be successfully implemented on industrial scale processing units.

The SASOL FT-Depropaniser

The FT-depropanizer is a total reflux 56-tray tower with a side draw section above tray 38. The purpose of the unit is to separate C_3s and lighter from heavier components.

The variables used to control the fractionation are primarily the feed-to-side draw ratio and the column pressure differential.

Control and optimization objectives

Maximize the side-draw product (C_3s) while maintaining the quality (no impurities such as C_4s)

Avoid flaring and column flooding from column pressure and delta-pressure high limits violations.

MPC-X Control Solution

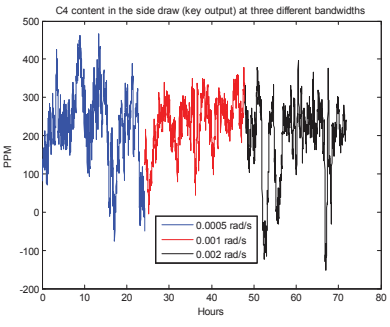
Primary MVs	Primary CVs
Feed-to-Side draw ratio	Side draw composition
Delta-pressure	Column bottom's temperature

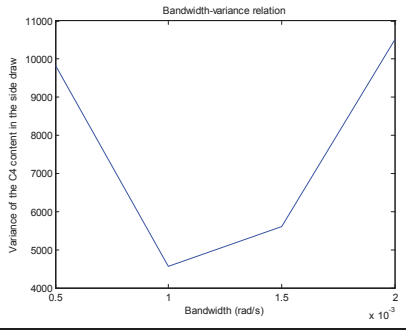
VALIDATION EXPERIMENTS

- **Establish initial conditions\benchmarks:** Open-loop binary step tests were executed and models were successfully identified. Initial tuning and performance benchmarks were established for MPC-X.
- **Manually force a plant-model mismatch:** Changes to the MPC-X model poles and gains were made.
- **Performance improvements via tuning:** After the plant-model mismatch was forced and the consequent performance drop established; MPC-X tuning changes were made.
- **Performance improvement via closed-loop step tests and re-identification:** Minimally disturbing excitation signals were executed under closed-loop conditions for model re-identification

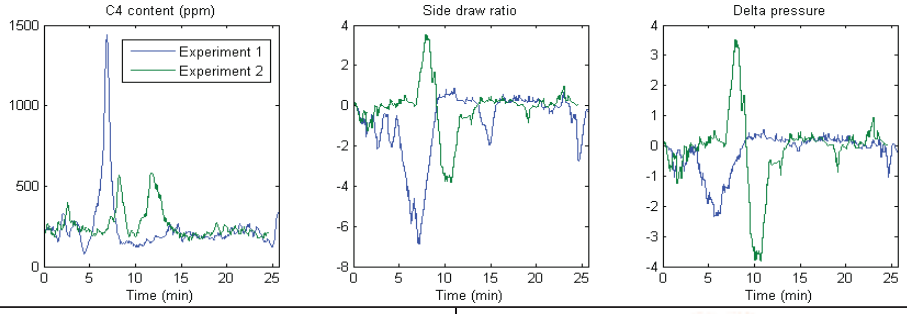
RESULTS

Tuning

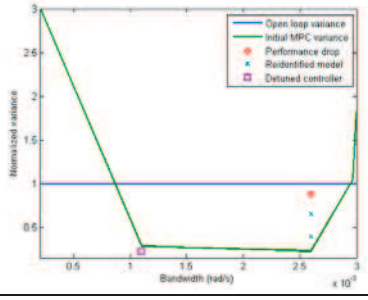




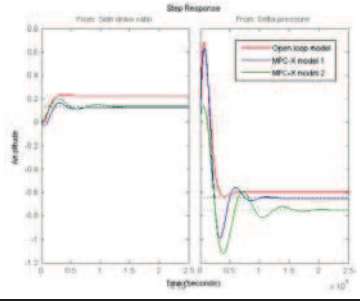
Closed loop excitation



Performance



Model Identification and Validation



Coordinator Contact: Prof. dr. ir. Paul Van den Hof, Delft University of Technology, P.M.J.vandenhof@tue.nl