Advanced Process Control

Handling Delayed Coker Disturbances with APC

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Delayed Coker Unit Overview

- Lumus Technology
- 2 Heaters and 4 Coke Drums
- 24 hour Cycle Time
- Drum Switch Every 12 hours
Impact of Semi-batch Operation on Fractionator

- Two Drum Switches in 24 Hours
- Main Fractionator is continuously disturbed
DCU-APC Challenges

- Semi-batch operation
  - Disturbances caused by drum switch and vapor-heating
  - Continuous changes in mass and enthalpy feed
- Drum switches involve manual operations in the field
  - Extent of disturbance changes in each event
- Unmeasured disturbances
  - Absence of Drum Vapor Flow measurement
- Continuous Operator attention and intervention
- Step test is difficult and takes longer time
- Feed Maximization: Coke drum capacity utilization
Design Concepts

- Automatic Drum Switch (discrete) Events Detection
- Generation of Drum Switch disturbance functions
- Use of Drum switch disturbances for Step Response modeling
- Intermediate variables for handling unmeasured disturbances (Robust Control)
- Feed forward predictive control during Drum Switch events
Drum Switch Events

- Two Drum pairs: A-B and C-D
- Drum Switch AB, BA, CD, DC
  - Event 1 – Vapor heating starts
  - Event 2 – Vapor heating ends
  - Event 3 – Drum Switch
  - Event 4 – Drum Switch ends

HCGO Draw Temperature (Deg C)
Drum Switch Disturbance Functions

- HCGO draw temp, °C
- DRUMSW_AB
- DRUMSW_CD
- VAPHEAT_AB
- VAPHEAT_CD

Graph showing time series data with time points from 02:30 to 02:30, intervals at 08:30 and 14:30, with specific disturbances marked at certain time points.
MISO Model Identification

HCGO-CR Step test and Multivariable model identification
Grey Box model: Intermediate Variables

- DrumSW_AB (DV) to reflux flow
- DrumSW_CD (DV) to reflux flow
- Vapheat_AB (DV) to reflux flow
- Vapheat_CD (DV) to reflux flow
- HCGO_CR (DV) to reflux flow
- HCGO_Temp SP (DV) to reflux flow
- Top Temp SP (DV) to reflux flow
- Top Reflux Temp (DV) to reflux flow
- LCGO draw flow SP (MV)

Predicted reflux flow

Reflux flow (measurement)

Updated reflux flow prediction

LCGO draw flow to LCGO tray-level

Predicted LCGO tray-level

Updated LCGO flow tray-level prediction

Kalman filter

LGO tray-level (measurement)
Two Main Controllers each with 2 sub-controllers
- DCU feed controller; sub-controllers: F001A, F001B
- Fractionator & Vapor Recovery Section

Automatic detection of Vapor Heating and Drum Switch Events

Drum Cycle time module for Feed Maximization

Inferentials: Light Coker Gas Oil (LCGO) D95%, LCGO Flash Point, Light Naphtha (LN) D95%, Heavy Naphtha (HN) D95% & LPG Weathering
DCU Feed Controller

- Maintain the specified unit throughput or maximize throughput within range if desired.
- Pass balancing heaters F001A and F001B
- Maintain pass flow deviations within range while honoring skin temperature constraints
DCU Main Fractionator Controller

- Maintain product qualities within specified limits and ensure smooth operation during disturbances in vapor feed flow and temperature due to semi-batch coking operation
- Maximize LCGO yield
- Minimize Coker Naphtha
- Maximize LCGO CR for heat recovery
DCU APC-Objectives

DCU Vapor Recovery Section Controller

- Maintain product qualities within specified limits and ensure smooth operation during disturbances in vapor feed flow and temperature due to semi-batch coking operation
- Minimize steam consumption in stripper reboiler
- Maximize LPG recovery in Gas Concentration section while preventing over absorption of lighter components
- Maximize LPG yield
APC: Feed forward Disturbance Rejection
APC Benefits

- Process stabilization: Reduction in Variance of key operating conditions
- Yield improvement of Value Added Product (LPG & LCGO)
- Throughput Maximization by better Utilization of Drum Space within Specified Cycle Time
- Minimum Operator intervention in particular during Drum Switches.

Detailed article:
http://www.digitalrefining.com/article/1001312,Handling_delayed_coker_disturbances_with_APC.html