Achieving Operational Excellence on a Delayed Coking APC Project

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Speaker Introduction, John Ward

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- B.S. ChE, M.B.A., M.A. Philosophy
- 30+ Years Global Refining/Petrochemical experience
- Process Engineer by Training
- Operated refineries with Texaco/Motiva. Designed refineries for M.W. Kellogg/KBR
- Catalyst, Licensing, Plant Startup for Haldor Topsoe
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Introduction

• Process Overview

• Successful APC Execution Plan

• Business Results Achieved

• Summary
Process Overview - PFD
Process Overview - PFD
Process Overview Summary

• Challenges:
  – Continuous process with significant cyclic disturbances
    • Inconsistent operator response to process disturbances
    • Product quality and yield variation

• Project Objectives:
  – Compensate for disturbances
  – Maximize LCGO production
  – Minimize product quality variation (Naphtha, LCGO)

• APC facilitates:
  – Automates and optimizes “Best operator responses”
  – Control loops in desired modes
  – Minimize operator intervention
Process Overview – Disturbances

• **Unmeasured & Unquantified** Process Disturbances
  – Drum Cycles
    • Backwarm
    • Drum Switches
  – HCGO Pall Filter Switches
    • HCGO pumparounds integrated into the product circuit
      – Amplified the effects of **HOURLY** Pall filter switches

• **Control Induced Variability**
  – Feed pump spillback pressure control valve
  – Tower reflux flow control valve
APC Development

- Justification
  - Internal Sponsorship
  - ROI Assessment
- System Preparation
  - Control Foundation Analysis & Improvement
- APC Execution
  - Embedded MPC and SmartProcess® Composites
  - Model Identification & Validation
  - Optimizer Objective Function Definition
- Quantify Benefits
System Preparation – Control Foundation

- Analyze key control loops, not just tune loops!
- Improve PROCESS performance not just “LOOP” performance
- Review control configuration and scheme
- Maximize PROCESS performance
System Preparation – Control Foundation

• Field walk down
  – Assess equipment installation against best practices
  – Assess general type and condition of control valves and instrumentation

• Conduct Operator interviews
  – Facilitates better understanding of the process
  – Understand control problems and operator responses

• APC Project Scope
• Reviewed and analyzed 30 key loops
  – Found issues with 3 key instruments and 2 critical valves
  – “Significant” (>30%) tuning changes on 27 of 30 loops
  – Recommended new control scheme on critical equipment
Tuning Procedure

• Step 1: Identify the basic process type
  – Self-regulating
  – Integrating

• Step 2: Measure process dynamics
  – Must use %Process Variable (%PV) and %OUT
  – \%\Delta PV = \Delta PV_{Eng\_Units}*(100%/Span_{PV\_Eng\_Units})
  – \%\Delta OUT= \Delta OUT_{Eng\_Units}*(100%/Span_{OUT\_Units})

• Step 3: Choose desired closed loop response time, “Lambda”

• Step 4: Calculate tuning constants
System Preparation – Control Foundation

As-found tuning
50% reduction in variability

As-found tuning ➔ As-left tuning
66% reduction in variability

As-found tuning

As-left tuning
66% reduction in variability
System Preparation – Control Foundation

Before Repair Valve Readback

After Repair Valve Readback

Fractionator Reflux Control Valve (Temp to Flow Cascade)
Rules of Thumb

• Largest opportunity for final elements is to minimize resolution, deadband and variation in response time.
• Largest opportunity for measurements is the selection and installation of sensors.
• Check the life-cycle cost
• Use smart transmitters.
• Deadtime limits control capability, design carefully to minimize
Rules of Thumb

• Use cascade, feed-forward and decoupling when appropriate
• Change control scheme when required
• An open-loop process identification method helps identify non-linearities in the loop (valve, measurement, etc.)
• A closed-loop tuning method can be a faster and safer way to identify process dynamics if non-linearities are not significant
Rules of Thumb

• Processes benefit from coordinated response of all loops in a system using Lambda tuning techniques

• Some loops require aggressive tuning

• Manage resonance of control loops.

• Now you are ready for APC!
APC Execution – Control Foundation

• Results
  – Significant (>30%) reduction in variability on 10/30 of the loops
  – Found opportunity for small MPC to increase waste heat recovery - $70K/year benefit!
  – Identified critical valves that required maintenance

• Reduces time required to implement APC

• Increases benefit of APC projects
  – Coordinated control loop responses contribute to project success

• Provides 25-50% of benefit of total APC project!
APC Execution - SmartProcess®

- Functional Design
- Det. Design, Config & Staging
- Step Tests & Model ID
- Commissioning

Traditional APC Technology

- Functional Design
- Det. Design & Config
- Step Tests & Model ID
- Commissioning

Embedded APC Technology

- F.D. & Config
- Step Tests & Model ID
- Commissioning

SmartProcess® Applications with Embedded APC

Implement in ¼ the time!
APC Execution – MPC Variables

- **Controlled Variables (CV)** - Process variables which are to be maintained at a specific value; i.e., the setpoint
  - Naphtha Draw Comp Temp
  - LCGO Draw Comp Temp
  - HCGO Draw Comp Temp

- **Manipulated Variables (MV)** – Controller setpoints written to by the MPC.
  - Ovhd Temp (TC751285)
  - Net LCGO (FIC751349)
  - Lean Oil to E7610 (FIC)
  - HCGO P/A (FIC751288)
  - Total Wash Oil (FC75

- **Constraints (LV)** - Variables which must be maintained within an operating range (a special type of CV)
  - Debut Reboiler Bypass Valve
  - Frac Ovhd Rec LIC Out
  - Sponge Oil Static Head
  - LCGO To Strpr Vlv
  - Etc.

- **Disturbance Variables (DV)** - Measured variables which may also affect the value of controlled variables
  - Backwarm (calculated)
  - Drum Switch (calculated)
  - Fresh Feed
  - Reflux Flow
  - Reflux Temp
  - Coke Drum Quench Temp
  - Etc.
APC Execution – MPC Process Models

• Measurements are not available for Backwarm and Drum Switch
• Created “calculated” DV’s for Backwarm and Drum Switch
• Backwarm
  – Reduction in heat input to the Fractionator
  – Change in composition to the Fractionator
  – Created a DV with scale 0-100%, reduce from 100 to 80 when triggered
• Drum Switch
  – Reduction in heat input to the Fractionator
  – Minor change in composition to the Fractionator
  – Created a DV with scale 0-100%, reduce from 100 to 70 when triggered
APC Execution – MPC Process Models

• Each DV triggered with key process variables and associated switching valves
• DV’s ramped slowly back to 100% after event to “re-arm”
• Calculated the models for both DV’s
  – Knowing approximately how much key MV's would move to compensate for the heat and composition change
  – Use the opposite amount of MV move, multiplied by know MV to CV/LV models to obtain the model from the calculated DV’s
APC Execution – Performance

Minimal deviation during major disturbance!
Business Results Achieved

• Eliminated operator intervention during coke drum backwarm and drum switch operations!
• The average LCGO production was increased by almost 5% of rate which resulted in a payback of 6 months for the project!
• Reduced downstream unit constraint
  – Shifted HCGO production to LCGO - Right barrels in the right place!
• Reduced Naphtha quality exceedances by 32%, LCGO by 40%
• ROI < 6 months!
• Management & Operators gained confidence in Advanced Control
  – More opportunities!
Summary

- APC can be successful on continuous process with large unmeasured disturbances
- Implementation plan ensures success
  - Project Sponsor
  - Benefit Assessment
  - Control Foundation Improvement
  - Embedded MCP and SmartProcess® Application Package saves time
- Reduced product quality exceedances by >32%
- ROI on project was 6 months!
- Identified other opportunities
- Questions