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An Integrated approach to Optimise Process Feed Quality Variations using Unisim and Profit Controller
Introduction

- An Integrated approach to Optimise Process Feed Quality Variations
  - Profit Controller & Unisim
- Case Study - Refinery Crude Switch
- Crude Switch and APC applications
- Crude Switch Optimizer solution
- Applications of Integrated Approach
Crude Switch and APC Applications

- Global uncertainties in crude pricing and availability
- Refineries processes crudes of varying types and compositions
- Advanced Process Control (APC) implementation is very common in Crude Distillation unit (CDU)
  - APC strategies are designed for a fixed set of crudes
- During crude switch, CDU product properties change drastically depending on the crude type
- Crude Switch affect the APC performance and can drastically reduce the benefits
Crude Switch and APC Applications

• During crude switch, accurate and reliable inferentials for product properties are not available
• Soft Sensors predictions for product qualities are way OFF and hence poor control performance
• APC applications are turned OFF during a crude switch
  – Throughput reduction and off-spec products
  – Can extend up to 6-8 hours depending on type of crude switch
• Crude switch is a transient control problem
• A long range Disturbance affecting CDU operation
Crude Distillation Unit – Control Overview

• CDU is a Multi Component Distillation Column
  – Product separation is based on difference in Boiling Points

• Complex interactive problem with more constraints than variables to adjust

• APC Objectives
  – Maximize Products
  – Meet product specifications
  – Minimize Fuel Gas

• Constraints:
  – ASTM 90% Cut Points – Naphtha, Kerosene, Gas Oil
  – Flash Point – Heavy Naphtha, Kerosene, Jet Fuel
  – Overhead Condenser duty, Overflash, etc
APC in Crude Distillation Unit

- Top Temperature Control
- Condenser Duty Calculation
- Pumparound Duty Control
- Product cutpoints
- Product qualities
- Overflash
- Tower flooding
- Valve positions
- Tower pressure
- Top temperature
- Furnace COT
- Product flowrates
- Pumparound duties
- Feedrate
- Non-linear Level Control
- Sidestream Cutpoint Calculations
- Product Property Calculations
- Steam
- CVs
- MVs
- AI
- TC
- PC
- FC
- TI
- LC
- MVs
- CVs
What happens in CDU during Crude Switch?

- Crudes are characterized by True Boiling Point curve (TBP) that determine the product yield.
- Product draw temperature determines the product cut point temperatures and thus quality.
- Change in TBP curve occurs as the new crude hits the column.
- This alters temperature profile in the column and product cut points used to infer product quality.
- TBP curve of the actual crude processed changes continuously; difficult to calculate the product properties.
- As a result, APC is switched OFF during crude switch.
Crude TBP Curve during Switchover

Crude TBP Curve changes drastically!
Existing Solution for handling Crude Switch

- Use Empirical equations to estimate a linear TBP curve using heat balance and temperature profile of the column
- Break the TBP curve into 2/3 cuts based on measurements

**Drawbacks:**

- Actual TBP curve is not calculated → inferential predictions are way off!
- Continuous product properties are not available from analyzers or lab during switchover
- Does not account for crude quality changes or new crude
- Does not consider mass balance, pumparounds and fractionation effects

Most of the time APC is switched OFF!
Crude Switch Optimizer Solution (1)

• A rigorous simulation model in Unisim Design based on first principles to calculate crude product properties during crude switch based on actual crude composition

• Unisim Socket Bridge to integrate offline Unisim Design with online Profit Controller
  – Extract the inferential properties from Unisim model and provides to Profit Controller
  – Automate execution of Unisim model in every execution of Profit Controller

• Crude Switch Optimizer Toolkit is "plugged on" to Crude Unit Profit Controllers
Crude Switch Optimizer - Workflow

First Principle Model
- Vapor Liquid Equilibrium
- Mass Balance
- Energy Balance
- Component Balance
- Property Calculations

USD Socket Bridge

Unisim Design Model

Crude Switch Optimizer Toolkit

Profit Controller 1
Profit Controller 2
Profit Controller 3
Profit Controller n

Crude Feed Selection
- Crude 1
- Crude 2
- Crude 3
- Crude N

Crude Switch Optimizer Workflow
Crude Switch Optimizer Solution (2)

- Operator selects the Crude type being processed and switched over, ‘Mixed' crude being one of the options
- Crude Switch Optimizer coordinates the USD Socket for crude type and Unisim model to be invoked
- Profit Controller provides column operating conditions (Flows, Temperatures, Pressures) to Unisim model
- Unisim model calculates accurate product properties based on column conditions and actual crude mix
- Profit Controller runs based on accurate inferential for provided by Unisim model
- Since based on First Principles, robust enough to work through crude switches for any crude types
CDU Unisim Design model

- Rigorous model based on Thermodynamics
- Unisim Crude Oil Characterization module
Unisim - Crude Product TBP Curves

- Utility for calculating TBP Curves and Crude Product properties
Unisim – Databook

- Databook is connection to USD Socket
- Define Input & Output Process Data Tables
Unisim Socket Workflow

• Socket for real time data transfer between Unisim model and Profit Suite
Unisim Socket in Profit Suite

- Executes at same interval as Profit Controller in URT
- Invokes and executes the Unisim model
Unisim Socket in Profit Suite

- Input Values are passed to USD model

- Output Values are received from USD model
CDU Profit Controller with Crude Switch
Inferentials in Crude Switch Optimizer

Reduction in Crude Switch Transition Time
LGO Draw Flow in Crude Switch
Benefits of Crude Switch Optimizer

- Cuts the crude switch time by half or more (6-8 hours to 2-4 hours)
- Reduction in give-away on key product qualities
- Push to maximum constraints and maintains high throughput
- Typically over $1-2m/year extra benefits from APC
- Robust enough to work through crude switch for any crude type
- Can handle new crude types and changes in crude composition
- Benefits are more significant for refineries that processes diverse crude types
A note on Integrated Approach

• Unisim Design has many modules applicable for different process industries

• Very rigorous steady state simulation package

• Unisim Socket has many Execution Modes:
  – Simulation
  – Gain Extraction
  – Optimization
  – Integer Optimization
  – Data Reconciliation

• Can be used in many applications – Reaction systems, Property prediction, Grade transition, etc.
Other Applications of Integrated Approach

• Used in Ethylene Plant APC & Optimization
  – SPYRO model in Unisim for Furnace Yield & Severity

• Crude Switch Optimization
  – TBP Curve & Crude Property calculations in Unisim

• Soft Sensor Inferential Calculation
  – Any property can be inferred from Unisim Simulation

• FCC Reactor Yield calculation
  – Gains extracted using TBP Curve calculated in Unisim

• Data Reconciliation

• Unit & Plant wide Optimization