Industrial challenges and requirements for optimisation and control of the Shell case study

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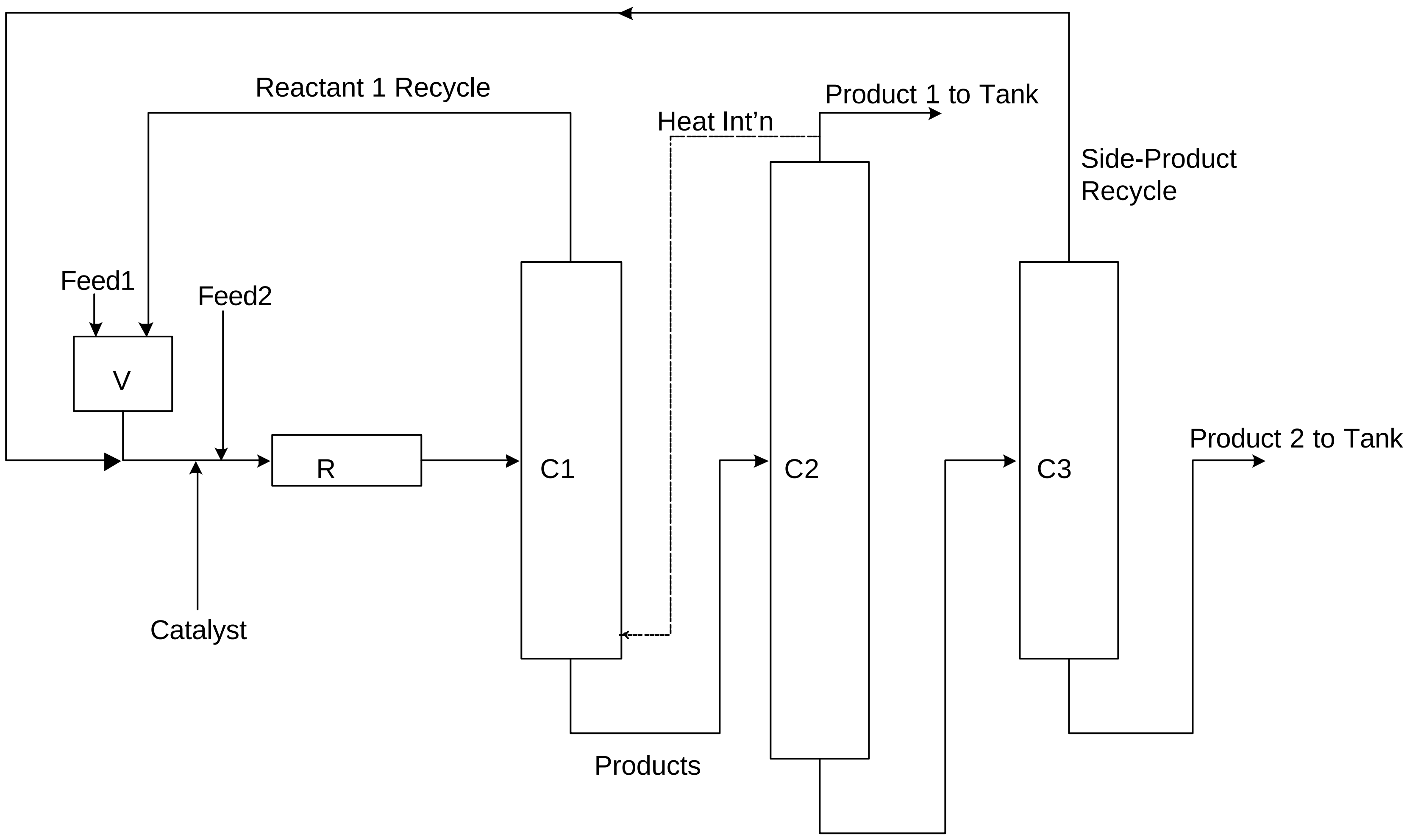
Shell Case Study

- Process Design, Operation and Economics
- Operational Requirements
- Objectives and Description of Case Study Work
- Industrial Constraints

Simplified Process Flow Sheet



Process Design and Requirements

- Two Product Streams
- Full Side-Product Removal
- Turndown 50%.
- Tight product specifications: high-purity separation required
- Equipped with Basic Regulatory Control and a few Quality Controllers
- Process behaviour is highly non-linear

Operational requirements and limitations

- V used to stabilise the short recycle.
- By-product recycle back to reactor feed, hence concerns on stability, quality.
- The inlet conditions of R are fixed. The delta T over R is controlled by catalyst feed.
- Reactant 2 feed to R must be fully converted.
- Heat integration: one of the condensers of C2 is combined with the reboiler of C1. Possibilities for decoupling are in place.

Case Study Objectives

- Improve control: faster disturbance rejection while maintaining stability and product qualities
- Minimise transition time between two steady states
- Implement recipes / targets generated off line
- Move process faster to new steady state
- Verify concept of hybrid dynamic modelling as reliable representation of actual process behaviour
- Prove capabilities of dynamic data reconciliation techniques
- Check requirements for process instrumentation
- Improve overall performance and profitablility of the process

Case Study Description of Work

- Develop dynamic process model
- Derive reduced models for control, estimation and optimisation
- Develop prototype software for control, estimation and optimisation
- Prepare test site, people, permits
- Perform field tests in three phases
- Measure performance indicators
- Validate results

Industrial requirements and limitations

- Confidentiality of process know-how
- Uncertainty of (economic) benefits to be reduced with field tests progressing
- Three Phases for Field Testing required:
  - Off-Line Simulation / Optimisation
  - On-Line Simulation / Open-Loop Operation (Manual Acceptance Mode)
  - On-Line Simulation / Closed-Loop Operation
- Results presented to and agreed with the process owner after each phase
- Tight schedule within 3-year duration of INCOOP

Process Economics

- Push throughput - as long as the market can absorb more product
- Run at full capacity; ramp up and down as fast as possible
- Selectivity: Side-product recycle flow and composition can be manipulated
- High-purity separation of Product 1 in C2
- Utilities (MP steam and catalyst feed)

Opportunities

- <u>*Throughput and throughput change*</u>
  Because of its plant-wide nature, this is an opportunity for DRTO.
- <u>*Selectivity*</u>
  An MPC can handle R, based on an appropriate model.
- <u>*Optimized product separation in C2*</u>
  Because of the heat integration, C1 and C2 have to be handled by one MPC application to minimise steam consumption and tighten product quality control.
- <u>*Large-recycle instability handling*</u>
  An MPC can improve stability and performance.

Available Dynamic Plant Model

- Aspen Plus steady-state model translated into Aspen Dynamics model using standard functionality & physical properties
- Developed in 3 months for basic version including basic-control layer adjustments and additional QC loops; 30,000 equations
- Benefits and Uses of the Model:
  - Simulate Behaviour and Disturbance Rejection of Whole Plant
  - Verify On-Spec Throughput Changes
  - Early Design Check for Safeguarding Settings, Control Tuning, etc.
  - Simulate Start-Up Behaviour
  - Operator Training & Manual

Shell Case Study

- New plant on existing site
- AspenPlus steady-state model made available by Shell as modelling basis for gPROMS dynamic rigorous model
- Aspen Dynamics / Custom Modeller dynamic model made available by Shell as reference (not fast or robust enough for on-line use; not transparent enough for model reduction)
- In-house modelling has shown strong interaction between long (hours-days) and short (minutes-hours) dynamic behaviour of the plant
- Market supply/demand situation will possibly dictate frequent, large load changes to be optimised by INCOOP technologies
- This presents a big challenge for INCOOP and gPROMS