بترو رابغ

Petro Rabigh

Petro Rabigh Uses Aspen Hybrid Models™ to Improve Margin and Reduce Operational Risk

aspentech | Case Study

11.3¢/bbl. of Feed

Increased Gross Margin

50% Reduction

in Time Needed to Update Planning Model

Significantly Reduced Operational Risk

CHALLENGE

Identify the most optimal production yields & qualities of their refinery and petrochemical products in the face of dwindling margins for refinery products.

SOLUTION

A high-fidelity hybrid model of Petro Rabigh's Fluid Catalytic Cracking (FCC) unit, leveraging a range of process simulation, and planning solutions, including **Aspen HYSYS®**, **Aspen Hybrid Models™** and **Aspen PIMS-AO™.**

BENEFITS

- Increased gross margin by 11.3¢/bbl. of feed
- Reduced the man hours needed to update the planning model by 50% (from 80 hours to 40)
- Improved accuracy of planning tools over a wider range of operations
- Reduced need for frequent updates
- Significantly reduced operational risks by leveraging new insights

Overview

Petro Rabigh (Rabigh Refining and Petrochemical Company) is a highly integrated refinery and petrochemical complex, producing more than 25 grades of fuels and polymers essential to transportation and plastics. Founded in 2005 as a joint venture between Saudi Aramco and Sumitomo Chemical, Petro Rabigh is located on Saudi Arabia's west coast and valued at close to $10B USD. It processes feeds of up to 21.2 MMTPA, refined products up to 14.9 MMTPA and petrochemicals up to 4.9 MMTPA (25% of the feed that goes into the complex is converted to petrochemicals). The complex is also comprised of 1.64 MMTPA ethane cracker, 92 KBD high olefin FCC (DCC) and 100 KBD petrochemical reformer (BTX).

Challenges: Competing Feed Distribution, Lost Margins and Cumbersome Workflows

The FCC unit and the ethane cracker were the two critical units of this complex, both complementing each other's operation for maximizing production of refinery products—hydrogen and petrochemical products. For example, the FCC unit produced almost 15% of the total ethylene and 95% of the total propylene produced in the complex. It also produces LCN (light cracked naphtha) and HCN (heavy cracked naphtha) used in the production of gasoline. Hence, the FCC could be either optimized to produce more petrochemicals (ethylene, propylene) or produce more refinery products (LCN & HCN).

Petro Rabigh used linear programming (LP) planning solutions to help the planning team with various strategic and tactical operations planning decisions, like determining the optimal throughput and severity of operations for the different process units.

However, the base delta variables used by these LP solutions could not accurately reflect the real-world, non-linearities in product yields and properties, making it difficult for Petro Rabigh to accurately predict the composition and properties of products from its FCC unit. Insights into potential product compositions were needed to operate the unit at its optimum level. Without these insights, the company missed out on opportunities for operational improvement and lost margin as a result of suboptimal operations.

The conventional LP model does a piece-wise linearization of the effects of operating conditions and feed qualities. This limits the range of controllable operations while planning. Additionally, the conventional iterative workflows for updating these planning models were complex and time consuming.

Solution: Non-Linear High-Fidelity Model of the FCC Meets the Challenge

The operation planners and engineers at the Petro Rabigh complex addressed these challenges by developing and deploying a non-linear high-fidelity model of the FCC unit in their Aspen PIMS-AO planning solution. The non-linear model of the FCC was built using Aspen HYSYS and Aspen Hybrid Models, which leverages both the accuracy of first principles-based simulation and the power of Industrial AI.

The hybrid model of the FCC unit was constructed by first building a rigorous process simulation model using the FCC kinetic reactor model template in Aspen HYSYS. The FCC process simulation model in Aspen HYSYS was then validated against plant data.

The validated HYSYS model was used to simulate over 2,500 cases using Aspen Multi-Case™, which enables users to run thousands of Aspen HYSYS case studies. The data generated was then used in Aspen AI Model Builder™ to develop the hybrid model of the FCC. The hybrid model was validated and then integrated into the Aspen PIMS-AO based planning solution.

Creating a Highly Accurate Hybrid Model

The Aspen Hybrid Model used 10 independent variables and 137 dependent variables. When the model's predictions were compared to real plant data, it showed a high level of accuracy with an R^2>0.97. See next column:

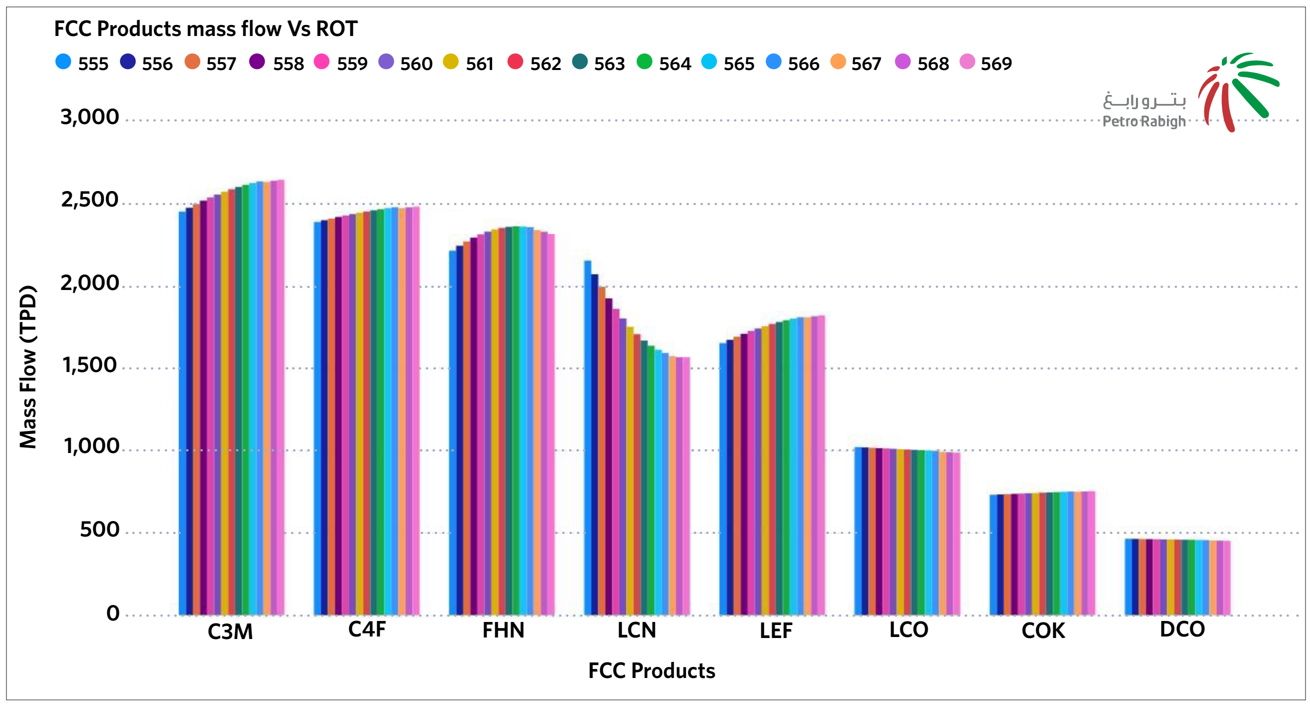
Independent Variables

1. Feed specific gravity
2. Feed sulfur content
3. Conradson carbon residue
4. Feed volume average boiling point
5. Percent of LCN recycled back to the reactor
6. Reactor plenum temperature
7. Light LCN cut point
8. Heavy LCN cut point
9. Feed flow rate
10. Feed pre-heat temperature

In addition to providing a high fidelity model of the FCC unit that could capture the non-linearities of real-world operations, the hybrid model helped users understand the relative importance of each independent variable to the dependent variables through the coefficient plots. For example, the plots showed that the LCN recycle rate had a more positive impact on the C3 Mix production rate than the reactor outlet temperature. Similarly, the LCN recycle rate had a larger negative impact on the FCC light cracked naphtha (LCN) production than the reactor outlet temperature.

After incorporating the hybrid model in Aspen PIMS-AO, Petro Rabigh's planning team was able to compare the effect of reactor outlet temperature on the yields of various FCC products. The data clearly demonstrated the accuracy of Aspen Hybrid Models in capturing the non-linearity in the real-world process.

Non-Linearities in FCC Product Yields Predicted Using Aspen Hybrid Models with Aspen PIMS-AO



Summary

The significant improvement in accuracy provided by Aspen Hybrid Models & Aspen PIMS-AO helped Petro Rabigh increase the accuracy of predictions for product yields and properties. The improvements in the accuracy of planning models reduced the gap between the plan and actual operations.

In addition to the accuracy improvements, the FCC Hybrid model provided better insights into the unit's operation. These improvements resulted in Petro Rabigh increasing its gross margin by 11.3¢/bbl. of the feed. The compa ny was also able to cut man hours required to update the planning model in half, from approximately 80 hours to 40 hours.

Additionally, Aspen Hybrid Models reduced the need for frequent updates for planning models, as the hybrid model covered a wider operating range and stayed accurate for a longer period. The integration of high-fidelity Aspen Hybrid Models to the Aspen PIMS-AO model had no negative impact on the model's runtime. In fact, Aspen PIMS-AO ran at the same speed as the base delta vector-based model.

In the end, AspenTech's digital solutions have enabled Petro Rabigh to improve its refining and petrochemical manufacturing processes in a number of significant ways, including:

- Improved accuracy of Aspen PIMS-AO results due to closer prediction of yields and properties
- Improved understanding of operational correlations between different parameters
- Boosted confidence of operational planners to provide accurate, complete instructions
- Significantly reduced operational risks
- Streamlined workflow for generating a hybrid model

About Aspen Technology

Aspen Technology, Inc. (NASDAQ: AZPN) is a global software leader helping industries at the forefront of the world's dual challenge meet the increasing demand for resources from a rapidly growing population in a profitable and sustainable manner. AspenTech solutions address complex environments where it is critical to optimize the asset design, operation and maintenance lifecycle. Through our unique combination of deep domain expertise and innovation, customers in capital-intensive industries can run their assets safer, greener, longer and faster to improve their operational excellence.

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