Chevron: Refinery Identifies $4.4 Million in Annual Savings by Using Process Simulation Models to Perform Energy-Efficiency Assessment

Benefits

- Identified potential annual natural gas savings of more than 25,000 MMBtu
- Found potential annual cost savings of $4.4 million
- Identified way to increase capacity of fluid catalytic cracking gas recovery units
- Found method to increase recovery of saleable light ends
- Identified means to improve quality of alkylation plant feed
- Found ways to decrease environmental emissions

Application

A Chevron refinery used simulation models of its light ends processing systems to predict the performance of different equipment configuration options and process modifications. This methodology can be applied to other industrial applications where process data can be used to validate the simulation model.

Summary

In an energy-efficiency study at its refinery near Salt Lake City, Utah, Chevron focused on light hydrocarbons processing. Normal refinery operation allows significant quantities of light hydrocarbons to enter the refinery fuel gas system. These hydrocarbons can reduce operating efficiencies for fired heaters and boilers by increasing plugging and fouling of the gas burner tips. It is possible, however, to recover the hydrocarbons from the fuel gas system and to sell them. Chevron used process simulation models of its light ends[1] distillation columns and associated reboilers and condensers to predict the performance of potential equipment configuration changes and process modifications. More than 25,000 million British thermal units (MMBtu) in natural gas could be saved annually if a debutanizer upgrade project and a new saturated gas plant project were completed. Together, these projects would save $4.4 million annually.

Public-Private Partnership

The U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP) cosponsored the assessment. DOE promotes plant-wide energy-efficiency assessments that will lead to improvements in industrial energy efficiency, productivity, and global competitiveness, and will reduce waste and environmental emissions. In this case, DOE contributed $100,000 of the total $400,000 assessment cost.

Plant Description

The Chevron Salt Lake City Refinery began operation in 1948 after the discovery of the Rangely crude oil field in Western Colorado. The refinery has run continuously as a 24-hour-per-day operation since startup in 1948, and currently employs about 200 workers. Crude oil, the refinery's major raw material, comes from Utah, Colorado, Wyoming, and Canada. Primary products produced at the facility include gasoline and other fuels, such as Jet-A, JP-8, and low-sulfur diesel. Minor products include stove oil, propane, and petroleum coke.

Several small processing plants compose the fully integrated Salt Lake City Refinery. Each of these plants plays an important role in making finished products. Each of the plants processes light hydrocarbons[2], such as propane, butane, and pentane. Figure 1 shows a simplified process flow diagram for the refinery.

[1] Light ends are low-boiling-point hydrocarbons in gasoline having up to five carbon atoms (or any extraneous low-boiling fraction in a refinery process stream). Saturated light ends are molecules that are fully saturated with hydrogen and thus do not have any double bonds between carbon atoms; these molecules do not react in an alkylation plant. They are produced in the crude unit, hydrotreaters, and the reformer. Unsaturated light ends are molecules that are not fully saturated with hydrogen and thus have double bonds between carbon atoms; these molecules readily react at the double bond in an alkylation plant. They are produced in the fluid catalytic cracking process and coker.

[2] Hydrocarbons are organic compounds mainly composed of carbon and hydrogen. Crude oil and natural gas are mixtures of hydrocarbons.

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The energy-efficiency study focused on the processing of light hydrocarbons. Normal refinery operation allows significant quantities of light hydrocarbons to enter the refinery fuel gas system. These compounds can reduce operating efficiencies for fired heaters and boilers by increasing plugging and fouling of the gas burner tips. Chevron, however, could recover the hydrocarbons from the fuel gas system into saleable products.

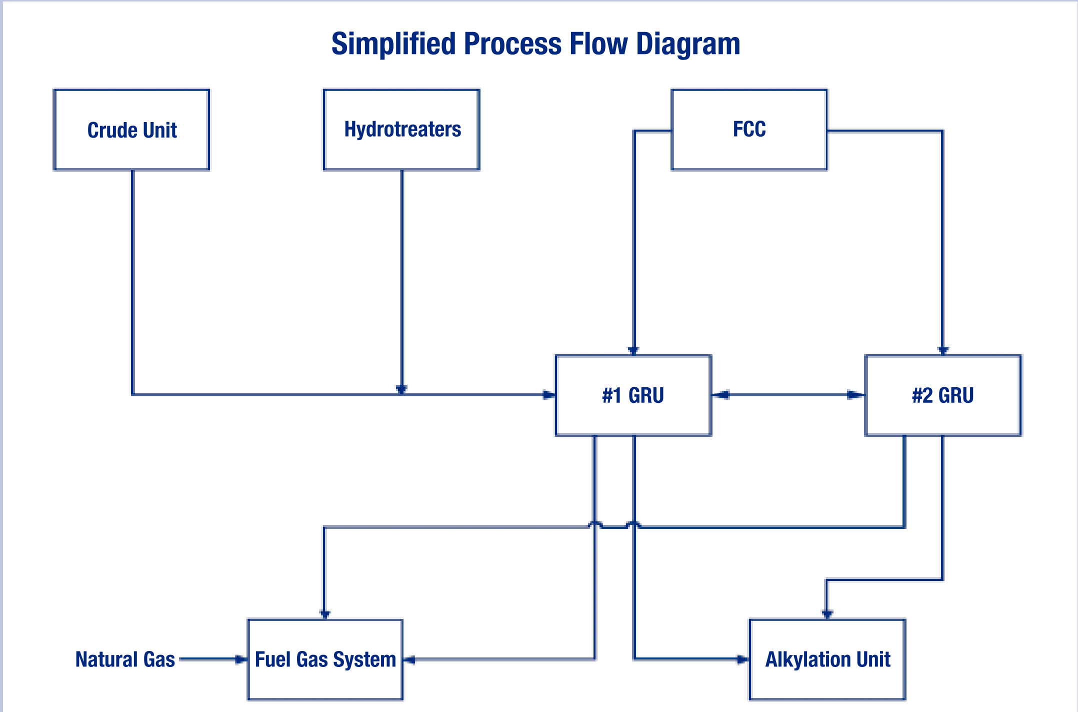

Figure 1. Process Flow Diagram for Chevron Salt Lake City Refinery

Assessment Approach

The energy assessment was based on process models that helped predict the performance of potential equipment configuration options and process modifications. To gain data as input for the models, the assessment team sampled 89 light ends process streams throughout the refinery. The process streams were sampled twice to account for seasonal variation in the data—once in the winter and once in the summer. The assessment team performed physical and chemical property tests, including simulated distillation, gas chromatograph, gravity, Reid Vapor Pressure (RVP), total sulfur, and sulfur speciation tests. The test results formed the basis for the economics and process modeling. In total, 19 refinery distillation columns were modeled in 6 different refinery process units.

A process engineering subcontractor, MPEC, Inc., completed the simulation models of the light ends distillation columns and associated reboilers and condensers. The physical and chemical sample test results and other process data – such as temperature, pressure, and flow rate – were compared with the model results. MPEC modified the model until the process data matched the model results. This approach helped to ensure that the model accurately reflected the actual process unit operation.

Results and Projects Identified

The assessment team identified two projects as a result of the Chevron energy-efficiency study, which are summarized in Table 1.

Table 1. Chevron Plant-Wide Assessment Results

Annual Projected Energy Savings		Annual Projected Economic Impact		
Project	**Natural Gas (MMBtu)**	**Savings ($)**	**Capital Cost ($)**	**Payback Period (yr)**
1. Install a larger FCC GRU debutanizer	5,528	800,000	700,000	0.9
2. Construct a saturated gas plant	20,000	3,600,000	15,000,000	4.2
Totals	**25,528**	**4,400,000**	**15,700,000**	**3.6 Aggregate Average**

Project 1

Chevron plans to install a larger debutanizer in the gas recovery units (GRU) that will allow plant personnel to improve the throughput of the fluid catalytic cracking (FCC)[3] process, increase recovery of saleable light ends, and produce higher quality feed material for the alkylation plant. The GRU is a distillation separation unit that fractionates light ends streams. A debutanizer is a distillation column that removes butane and lighter materials from a mixed stream of hydrocarbons. The alkylation plant uses an alkylation reaction to produce high-octane, low-vapor-pressure gasoline blend stock.

From the process modeling, the assessment team determined that the debutanizer limits throughput in one of two parallel FCC GRUs and that the de-ethanizer upstream of the debutanizer is underutilized. The de-ethanizer removes ethane and lighter material via distillation from a mixed stream of hydrocarbons. By replacing the current small debutanizer with a larger, idle debutanizer, Chevron can eliminate the bottleneck in one of the two parallel FCC GRUs. By recomissioning this larger debutanizer, the balance of the vapor and liquid between the two parallel GRUs can be improved, increasing recovery of light hydrocarbons. The plant operators control the flow of vapor and liquid between the two GRUs. A larger debutanizer will allow the operators to better adjust that flow, which will maximize use of the existing equipment and improve distillation quality.

The debutanizer processes light hydrocarbon streams from both the FCC and coker units. Plant operators can feed the coker stream either directly to fuel gas, or to the debutanizer column for further processing. By feeding more coker gas to the larger debutanizer column, Chevron can recover significant incremental quantities of light hydrocarbons from the refinery fuel gas system and sell them. The fuel gas stream could then be supplemented with natural gas. The refinery could get higher quality feed to the alkylation plant by using a larger debutanizer column that provides better butane-pentane splits. The improved butane-pentane splits would decrease alkylation polymer production, which would decrease polymer waste burning in the alkylation furnace. A cleaner alkylation furnace convection section would save fuel, and less polymer burning in the furnace would reduce emissions. The plant would also realize steam savings because the debutanizer feed preheat exchanger would be more efficient. The larger debutanizer would better utilize the feed-bottoms exchanger, yielding steam savings in the debutanizer reboiler. By putting the larger debutanizer in service, the refinery would also increase the FCC GRU capacity.

By completing this project, Chevron would save an estimated 5,528 MMBtu per year in natural gas and $800,000 per year in costs. Capital cost of the project is estimated at $700,000.

[3] Fluid catalytic cracking is the catalytic conversion of heavier and more complex hydrocarbons into lighter products and coke in a fluidized bed catalytic reactor with continuous catalyst regeneration to increase the yield of lighter products from crude oil.

Project 2

The assessment team also identified a project to construct a new saturated gas plant. This facility would process all of the saturated light ends that come from the crude unit, hydrotreaters, and reformer. The unsaturated light ends, which are produced in the FCC and coker, would be processed in the existing FCC GRU, thus increasing FCC throughput. Only the unsaturated gas from the FCC GRU would be fed to the alkylation plant, which would improve feed material quality. Chevron would sell the saturated gas from the saturated gas plant as an end product. Separating the saturated gas from the unsaturated gas would save energy costs by avoiding reprocessing of the saturated gas in the alkylation plant. It would also eliminate the bottleneck in the alkylation plant because only the unsaturated gas would have to be processed.

By completing this project, Chevron would save an estimated 20,000 MMBtu per year in natural gas and $3.6 million per year in costs. Capital cost of the project is estimated at $15 million.

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