On-line Process Optimization at the Western Gas Resources Granger Plant

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ABSTRACT

Western Gas Resources, Inc. (WGR) has embarked on a business improvement initiative at the Granger, WY processing asset. The initiative includes on-line model-based process optimization provided by eSimulation Inc. The Granger plant was chosen for optimization because of its size and complexity. The plant processes almost 500 MMSCFD of gas using two Cryogenic processing units and two Refrigeration units. NGLs are fractionated to produce Ethane, Propane, Isobutane, N-Butane and Gasoline products for rack sales and excess product is sold as y-grade. The plant is staffed 24 hours per day.

The plant model was developed using the eSimOptimizer℠ web-based process optimization system. The model includes a rigorous chemical engineering model of the process as well as a detailed commercial model of the gas contracts associated with plant feeds. eSimOptimizer℠ continually collects and averages relevant process data. Every 3 hours, the data is used to update equipment performance tuning factors and optimize plant operating targets based on the latest product and residue pricing. The results are presented to the operators via simple tabular web pages. The results include both optimization target recommendations and the predicted economic impact of the changes.

This paper will describe the implementation and results of the eSimOptimizer℠ project at the Granger plant.

BUSINESS OPPORTUNITY

The Rockies producing region is currently one of the most active in the country with a large number of gas wells being completed each year. The Granger plant is centrally located within this region, has the capability to directly process close to 500 MMSCFD of gas, and can manage additional gas and liquids to produce:

- Residue Gas
- Ethane
- Propane
- Isobutane
- Normal Butane
- Natural Gasoline

The primary processing units at the Granger plant include inlet gas compression, stabilization and dehydration, 2 cryogenic (expander) plants, 2 refrigeration plants, product fractionation and treating. The Granger plant cannot process all the available gas at the plant and has alternative processing agreements for some portion of the gas. Residue from the Granger plant, from alternative processing, and from low-BTU gas bypassing the plant is blended. In addition to the liquids from the Granger plant, the fractionation plant also processes NGLs trucked in from outside sources. A block flow diagram of the Granger plant is shown in Figure 1 below.

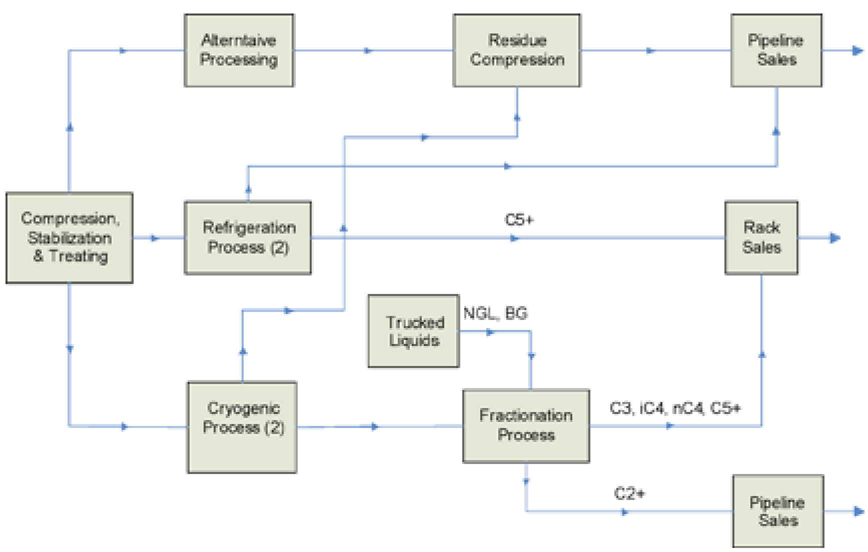

Figure 1 – Block Flow Diagram of the Western Gas Resources Granger Plant

In January 2004, eSimulation℠ was contracted to develop and implement an on-line optimization system to help the plant operators manage the complex economic and physical trade-offs associated with processing rich natural gas streams at Granger.

OPTIMIZER TECHNOLOGY DESCRIPTION

eSimOptimizer℠ is an online process optimization system designed specifically for mid-stream natural gas processing applications. eSimOptimizer℠ is a model based optimization system that includes a rigorous chemical engineering model of the plant combined with a detailed economic model of the business.

eSimOptimizer℠ is fed plant process data (temp, pres, flows, and analyzer signals) through eSimulation℠'s DataPumpTM system. The DataPump is an industry standard database application which can link to most electronic control systems. The DataPump averages the plant data and sends it to eSimulation℠'s data center via encrypted internet technology. The five minute averaged data is processed within eSimulation℠'s computer servers and stored in a large scale SQL database.

eSimulation℠'s engineers develop the eSimOptimizer℠ process and economic models as part of the project implementation procedure. On an every three hour basis, the plant data is loaded in the process model. The process model is then reconciled to calibrate it to current plant conditions (i.e. compressor efficiencies and heat transfer coefficients are calculated to reflect current equipment capability).

This calibrated model is then used as the basis for an optimization case run that considers process capability and current economics (i.e. contract mix for gas feeds, current residue and NGL prices). The results are presented to the operator in the form of suggested optimization move targets with the value of making those moves defined.

OPTIMIZER PROJECT DESCRIPTION

The optimizer scope includes both cryo plants, 1 refrigeration plant, residue compression, process refrigeration, and the complete fractionation plant (DC2, DC3, DC4 and DIB). The second refrigeration plant was not included because it is isolated from the operation and economics of the rest of the plant and the simplicity of the process does not lend itself to on-line optimization such as described here. For similar reasons, product treating units were not modeled rigorously owing to limited opportunity for real-time optimization benefits.

A half-day kickoff meeting was held at the plant in mid-February 2004 to discuss the physical process and its limitations. The commercial structure describing the inlet gas and plant products was also discussed. In addition, most of the information needed for modeling the plant was collected including:

- Updated P&IDs and PFDs
- Compressor and expander design information
- Heat exchanger design information
- Instrumentation/database lists
- Process graphic displays

Some required information was initially unavailable. This information had to be collected from third-parties, located in engineering files, or recorded off of equipment face-plates. In addition, some followup discussions were required with the commercial group in Denver to confirm the commercial model for the plant. The DataPumpTM computer and software was installed in late-March 2004 to initiate data historization and viewing capability. This also provided access to the process data required during the model building effort.

Once all the necessary information was collected and the data was coming into the web-site, the process modeling effort was initiated in late-May and the initial off-line model was completed in mid-July. At the time, the Granger model was the largest implemented by eSimulationSM . The size and complexity of the model made interfacing it to online plant data very challenging and time-consuming. However, following a substantial effort, the model was successfully interfaced to live data and tuned by early-September. However, robustness and execution time issues continued to cause problems with system reliability. After porting the application over to a higher-powered computer server, and eliminating unnecessary model detail from the model, the optimizer was ready for full commissioning in early-October. eSimulationSM spent several days on-site working with the operators to implement the suggested optimization targets and to validate plant performance against model predictions.

As the optimizer runtime increased, Western Gas questioned the model predictions in several areas. This is the normal learning/tuning process with the models and leads to better understanding of the key economic decisions and physical plant behavior. To address some of the modeling issues that were identified and to improve model reliability, eSimulationSM undertook a significant model revision that was completed in December 2004. By separating the model into several smaller/inter-connected models, model execution times were further reduced and model robustness was increased. A second tuning effort was made the first time the plant switched from recovery to rejection operation. The eSimOptimizerSM model has seen little substantial change, except for continued tuning, since that time. The eSimOptimizerSM system is provided as a fully supported service. All model revisions and tuning are included in the monthly service fee.

OPTIMIZER RESULTS PRESENTATION

The optimizer results are presented to the operators via secure web-pages. Access to these pages requires a username and password but is available anywhere the user has internet access. There are a number of web-displays that have been created to support this application. Separate web-pages provide optimization results for:

- Cryo Plants and Residue Compression
- DC2 and 2 DC3 Columns
- DC4 Column and, when operating, DIB Column
- Refrigeration Plant

An example of the Cryo Plant web-page is given in Figure 2 below.

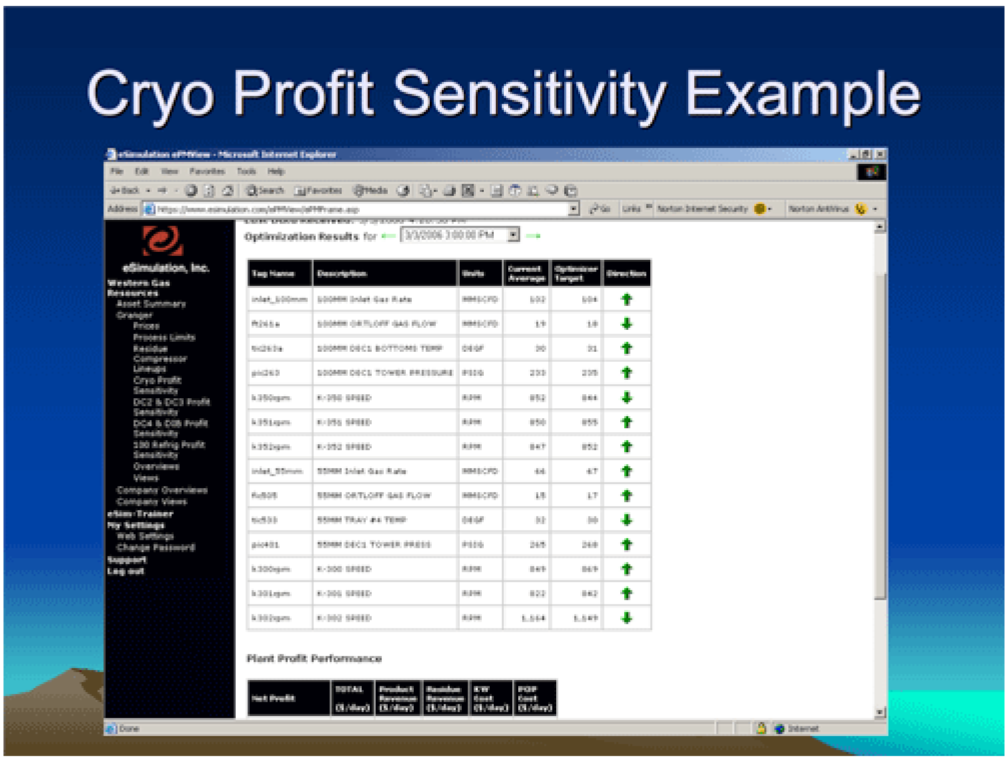

Figure 2 – Example Cryo Plant Profit Sensitivity Web Page

The web-page is designed to give the operator recommendations for changes to control system setpoints and to provide the economic impact of those changes. For each significant process setpoint, the Profit Sensitivity display shows the Current Value (usually a 3 hour average to better reflect the steady state), the Optimal Target and the expected economic impact that will result from making the suggested moves.

Besides the process data (pressures, temperatures, flows and compositions) the other inputs needed to derive the optimizer are entered via other web pages. The input pages for this application include:

- Edit Prices – provide commodity prices and gas contract details
- Edit Limits – provide operating limits and product specification details
- Edit Compressor Lineups – provide details to properly configure residue compressors

By simply tabbing to the appropriate entry, this data can be entered directly into the database for use by the eSimOptimizer℠ model. An example of the Edit Limits page is given in Figure 3 below:

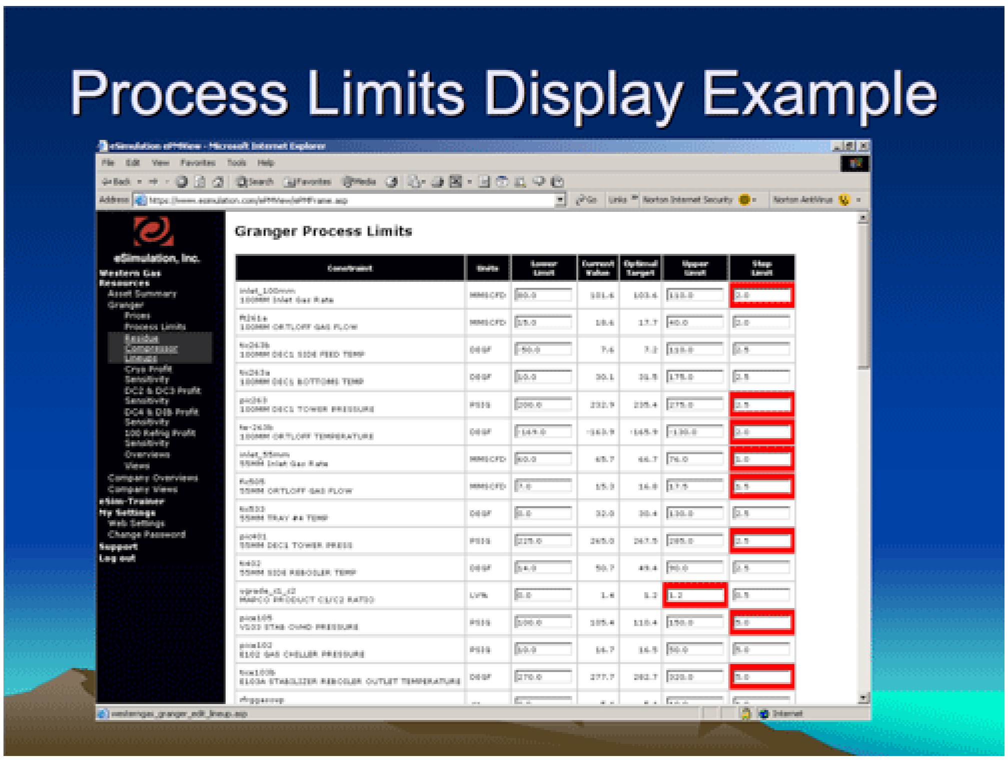

Figure 3 – Example Optimizer Limits Web Page

Note that the limits page is also used to highlight the limits that the optimizer is hitting on a particular run. Typically, the optimizer is initially limited by the 'Step Limit' which is the maximum amount a variable is allowed to move in a 3 hour period (ie, between optimization runs). Ultimately if the targets are followed, the optimizer will begin to hit 'Upper Limit' and 'Lower Limit' values. It is important to periodically review these constraining limits as the optimizer can achieve additional value if the limits can be safely relaxed.

The eSimulation℠ business model recognizes that you cannot simply 'turn-over' this sort of technology and expect it to achieve maximum value, or even sustain any initial value that is captured, without a comprehensive support strategy. eSimulation℠ engineers continue to support the eSimOptimizer℠ application for the duration of the contract term. As part of this on-going support effort, eSimulation℠ continues to maintain and improve the system (model and dataflow), responds to operator and management questions regarding optimization results, and provides periodic reviews of optimization recommendations. An example is given in Figure 4 below:

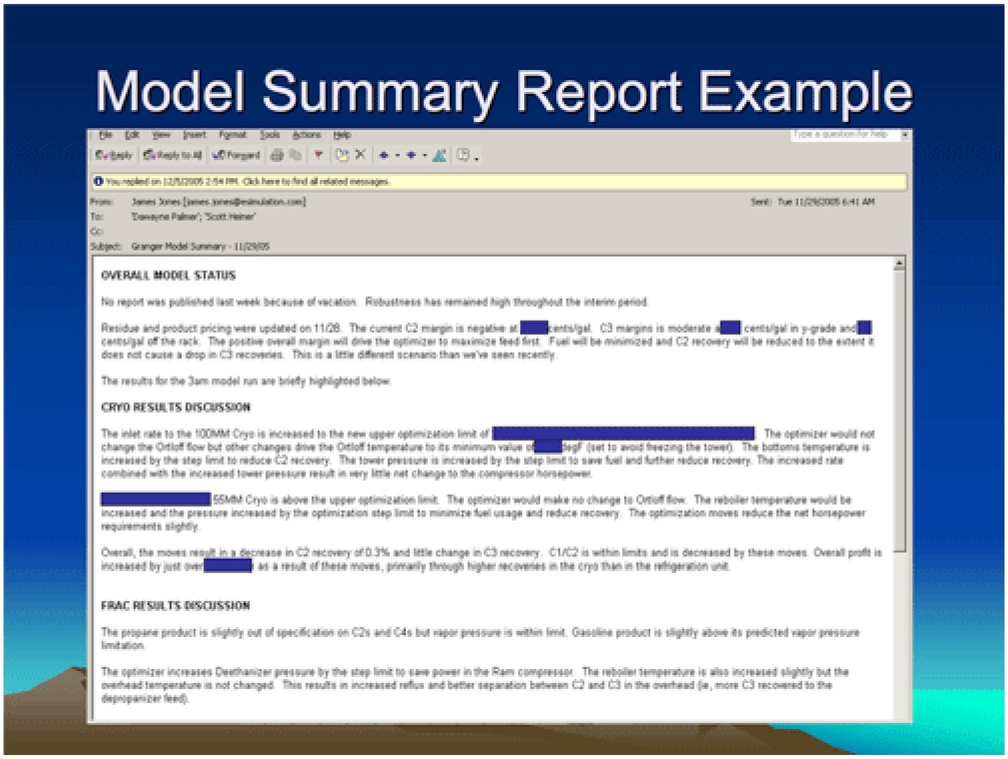

Figure 4 – Example Model Summary Report

OPTIMIZER ECONOMIC RESULTS

Another part of the included system support is to periodically attempt to quantify the value captured by the plant from using the optimizer technology. A value analysis was completed for the Granger eSimOptimizer℠ system in September, 2005. To provide an independent measurement of the optimization results, Plant Daily Report data was utilized for both baseline and post-optimization data.

The results for November, 2004 to February, 2005 were inconclusive as there continued to be some model shake-out during that period. Starting in March, 2005 through August, 2005, the monthly benefits were consistent at approximately 0.46 cents/mcf inlet gas. This benefit was achieved without letting the optimizer manipulate inlet rate. The results are given in Table 1 below:

Evaluation		**Profit Uplift (cents/mcf) without Throughput**

Period		**Credit**
August, 2005		0.444
July, 2005		0.635
June, 2005		0.655
May, 2005		0.421
April, 2005		0.324
March, 2005		0.298

Table 1 – Value Calculated from Analysis of Daily Reports

Beginning in June 2005, the optimizer was allowed to manipulate the Cryo Unit feed rates within limits. In June and August, mechanical problems related to the residue compressors prevented the full benefit of this feed rate increase to be realized by Western Gas. However, in July 2005 the optimizer was able to push and maintain the plant at higher rates for extended periods. The additional inlet gas processed in the Cryos (instead of the Refrigeration Plant) resulted in an economic uplift of 2.628 cents/mcf owing to the additional recovery in the Cryo Units.

To accomplish the rate increase within the horsepower limitations of the residue compressors required the tower pressures to be increased somewhat. This directionally reduced the C2 recovery in the Cryo units. However, when overall plant recovery is considered (including all processed gas), the effective C2 recovery is actually increased by processing more in the Cryos and less in the Refrigeration plant or bypass.

Unrelated mechanical problems have prevented us from consistently achieving the rate benefit. However, this is a potential benefit whenever the plant has the capability to sustain the moves and when the optimizer provides the economic justification needed to push the plant beyond the point where recoveries begin to be affected.

SUMMARY

A real-time optimizer has been implemented for the Western Gas Granger Processing plant. The commissioned application runs every 3 hours, 24 hours/day, 7 days/week. Occasional system failures, usually resulting from temporary plant upsets, are corrected by eSimulation℠ engineers as part of standard system support. In addition, eSimulation℠ provides minor model enhancements, explanation of results, and periodic value analysis. The most recent results show benefits of approximately 0.46 cents/mcf for the cryo units. If feed is optimized, the benefits increase to as much as 2.62 cents/mcf. Additional benefits are captured in the fractionation plant but these have not been quantified. eSimulation℠ and Western Gas are in discussion about extending this work to other plants within the system.