Alternatives to Optimize Gas Processing Operations

Mark E. Roop

eSimulation, Inc.

Houston, Texas, U.S.A.

Jean Leger

Enogex, Inc.

Oklahoma City, Oklahoma, U.S.A.

Steve Hendon

eSimulation, Inc.

Houston, Texas, U.S.A.

CHALLENGES AND REQUIREMENTS

Gas processing companies operate facilities that can benefit from advanced technologies developed for the refining, chemical, and petrochemical industries. However, the viability of these technologies for gas processing operations is a concern given the following challenges:

1. The contract mix at the front end of the plant is varied and complex making it difficult to determine and maintain an optimal operational strategy for the unit.
2. The contract mix can dictate how much money the processor can invest in upgrading the facilities with advanced technologies. Technologies justified on a 6 - 12 month payback basis for a refining industry may require a five-year payback period for a gas processing plant.
3. Advanced technology solutions designed for large scale refining and petrochemical facilities may be only viable for the largest of gas processing units. Gas processors typically manage plants with varying capacities and all must be coordinated to achieve overall profit maximums.
4. Processors often run with minimal process engineering resources to troubleshoot and enhance unit performance. The engineering resources, typically centralized and responsible for several process units, do not typically have the bandwidth to maintain onsite advanced technology solutions.
5. Management is responsible for supporting several facilities from a central location. The consolidation that has taken place in the mid-stream business requires processors to manage plants with varying control infrastructure. Process optimization is put on the back burner when management is challenged with simply establishing a window into process operations.

6. Operational practices are often imbedded in the philosophy of the company which can result in reduced asset profit contribution i.e. maximize recoveries at all costs.

The result of these challenges is that processors are often "flying blind". They have limited indication of the financial impact of their decision making process and little guidance for maximizing the profit contribution of the facility. The technological requirements of the individual disciplines supporting the plant are summarized in Table 1:

Table 1, Part 1 - Gas Processing Requirements

Operations
• Current vs. optimal process profit performance
• Guidance to achieve optimal performance
• Decision support for local troubleshooting of process problems
• Sound control infrastructure

Table 1, Part 2 - Gas Processing Requirements

Process Engineering
• Window into the process
• Performance monitoring for individual process equipment and the entire plant
• Remote troubleshooting ability
• Identify the financial impact of equipment performance degradation
• Analysis of the constraints the facility is working within

and an indication of the financial benefit of removing those constraints

Management
• Window into the process
• Summary of asset performance for each plant
• Ability to "drill down" and monitor what is happening at each plant.
• Highly value adding, robust, and maintainable solutions

Most importantly, technology solutions must be cost effective and viable for the full range of processing assets (not just the large facilities).

Several advanced technology solutions are available to help operations, engineering, and management improve the profitability of the unit. The solutions presented in Table 2 below have been applied extensively for large scale refining, petrochemical, and chemical operations.

Table 2 - Technology Solutions

Process Historians	Advanced regulatory control
Multivariable predictive control	Neural network controllers
Off-line process simulators	On-line sequential simulation
On-line equation based optimization	Linear programs

While the success of these technologies is well documented for refining, petrochemical, and chemical applications, the question remains as to their viability for the gas processing industry. The following lists the pros and cons of each of these technologies as related to the gas processing business.

Process Historians

Pros - Process Historians gather data from the plant's Distributed Control System (DCS) and allow for analysis, trending, and archiving of process data. Process Historian are DCS independent and can serve as a remote, single window, interface into many plant assets.

Cons - Process Historians require local hardware and software as well as installation, configuration, and maintenance services which can be difficult to justify for small to mid-sized plants. Process Historians capture historical events but provide little guidance on how to improve the profitability of the plant.

Advanced Regulatory Control

Pros - Advanced regulatory control algorithms are programmed into the DCS and help the plant address dynamic conditions and upsets. This technology is relatively inexpensive to implement and requires little, or no, additional hardware or software.

Cons - Advanced regulatory control algorithms are free form and can be difficult to maintain by anyone other than the person that designed, programmed, and commissioned them. The risk being that an application may be unsupportable when the person is promoted or leaves the company.

Advanced regulatory control strategies most often do not include economic based optimal targets for the unit. However, an advanced regulatory control strategy, when properly configured and supported, can help achieve the targets specified by an economic optimizer. Companies specializing in advanced regulatory control for gas processing plants have well developed, and effective, strategies. These offerings should be considered for those instances when the plant has difficulty managing process dynamics or maintaining optimal targets.

Multivariable Predictive Control

Pros - Multivariable controllers gather plant data from the DCS, process it, and then write setpoints to the DCS controllers. They use an empirical dynamic model of the process to guide the control response for an entire unit. Multivariable controllers can push the process to multiple simultaneous constraints defined by an economic optimizer. They add value by reducing the standard deviation of the key control variables in the process and allowing the process to be pushed closer to hard limits. Multivariable controllers are most easily justified when increased production credits can be taken.

Cons - Multivariable controllers require a hardware platform, a costly software component, and extensive engineering services to install, commission, and maintain the technology. Their empirical model is linear and application to the non-linear gas process requires additional manipulation. Further, multiple models may be needed to address different operational modes such as ethane rejection and ethane recovery. Multivariable controllers require a high level of plant automation and do not accommodate the manual moves operators sometime make to gas plant processes.

Multivariable controllers usually require a large facility that can take production increases to justify the cost of implementation and maintenance. This makes them unscalable to the smaller facilities typical of the gas processing industry, and even less viable for those plants that are not able to take the production increase credits due to commercial limitations. It is also easy to underestimate the amount of maintenance required to keep the model matching plant conditions.

Neural Network Controllers

Pros - Neural network based controllers are similar to multivariable controls except that they gather plant data from the DCS and use the data to "learn" the process. Neural Network controllers are said to handle non-linearities better than multivariable controllers and are less expensive to commission and maintain.

Cons - Neural network based models are only valid within the range of data in which they were trained. Changes inside the process such as a leaking JT valve would be outside of the range in which the model was trained and therefore the results may be suspect.

Refining and chemical companies have attempted using neural networks for control many times over the last 10 years. The technology hasn't proven to be viable compared to the other approaches such as advanced regulatory control and multivariable control.

Offline Process Simulators

Pros - Offline process simulators are used to develop a rigorous steady state or dynamic model of the process. They are used by process engineering personnel to design and troubleshoot processes. Offline simulations allow for what-if case studies to evaluate process enhancements and expansion opportunities.

Cons - Offline simulators are typically not used to support daily operational decisions. They must be updated and calibrated to actual plant conditions for every use. They are not as robust as equation based optimizers and can have difficulty converging large problems reliably and quickly.

On-line Sequential Optimization

Pros - A few of the offline simulation companies offer an inexpensive, sequential based, optimization system. The optimizer is based on a rigorous steady state model of the process and is typically less expensive than equation based systems. They leverage the work done to develop the offline model for online purposes.

Cons - The extended convergence times inherent in these systems bring into question the robustness of the technology. The sequential nature of the solving technology also can limit the scope of the system. These systems require hardware and software to be purchased, installed, commissioned, and maintained onsite and require specialized resources to support them.

Equation Based Optimization

Pros - Equation based optimizers use a rigorous steady state model of the process as the basis for optimization and include an automatic calibration of the model with each optimization run. The equation based solving technology allows optimizers to execute quickly and robustly making them viable for larger scale problems i.e. multiplant load optimization for plants on a common gathering system.

Cons - Equation based optimizers require a hardware platform, a costly software component, and highly specialized engineering services to install, commission, and maintain the technology. Closed loop implementation requires a multivariable controller to be installed to effectively achieve the optimal targets.

On-Line Equation Based Optimizers, when coupled with a Multivariable controller, represents the standard in optimization technology for refining and petrochemical industries. Most refiners and petrochemical companies are rapidly deploying this technology to improve the profit contribution of their larger scale processing facilities. Unfortunately for gas processors, this technology is justifiable only for very large gas processing facilities and is not scalable across their asset base.

Linear Programs

Pros - Linear Programs are used for evaluating feed and supply chain options. Linear programs are an offline tool that allows for what-if-case studies and evaluation of supply chain alternatives (i.e. what is the best way to supply liquids to the gulf coast?). They are relatively inexpensive.

Cons - Linear Programs provide a linear representation of the plant process and do not provide guidance for operators.

WEB BASED OPTIMIZATION

The aforementioned solutions individually do not address all the needs of the groups supporting gas-processing operations. When considered in combination, cost justification becomes the issue. The authors would like to suggest a novel alternative to optimizing gas processing facilities called web-based optimization.

The emergence of the internet as a robust communication medium has paved the way for technology to be delivered in a secure, robust, and inexpensive fashion via the Application Service Provider (ASP) business model. The ASP approach allows technology to be centralized for ease of deployment and maintenance. Most importantly, it allows equation-based optimization technology to be delivered to gas processors in a very cost effective fashion. The ASP architecture as applied to web-based optimization is depicted in Figure 1.

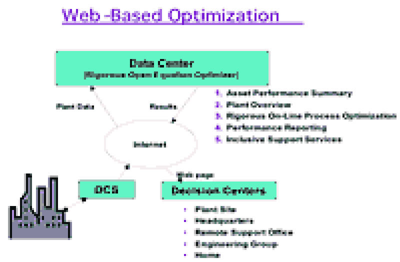

Figure 1 - Web-based optimization

The web-based optimizer gathers plant data from the DCS, or Human Machine Interface (HMI) database, using an industry standard protocol and transfers it to a data center via the internet. The transferred data includes plant pressures, temperatures, flows, and analyzer signals.

Once in the data center, the plant data is transferred into a relational data base and then processed using a rigorous equation based optimizer. The optimizer is first calibrated to actual plant conditions and equipment performance parameters such as heat transfer coefficients, compressor efficiencies, pressure drops, and distillation efficiencies are calculated. These calculated performance parameters are then compared to design values to provide an indication of the cost of performance degradation.

After the rigorous model has been calibrated to actual conditions (not design), the optimizer is run a second time to calculate economic based optimal targets for the "handles" which can be adjusted to improve profitability. For example, a cryogenic gas plant may allow adjustments to boost pressure, demethanizer bottoms temperature, and in some cases, expander speed. The significance of the optimization step is that feed and product pricing are considered as well as all the economic and operational constraints the facility works within.

The optimizer offers additional guidance to operators by displaying profit sensitivities that identify the financial impact of each process move towards the optimal targets. This way, the operator can focus on those moves that will have the most impact on unit profitability. In practice, the operator makes the suggested moves, and then receives feedback on how the moves affected the overall profitability of the unit. Once the unit has settled, the operator receives new targets that consider then current ambient, feed, and pricing conditions. The operator uses this information to minimize the current vs. optimal performance delta for the unit.

The results are displayed on a simple, easy to use, and secure web page. The web page allows for plant performance data to be accessible from any location with a PC and standard web browser. The optimizer's results can then be viewed, and used, by the various organizations responsible for improving unit profitability.

Each user is assigned a unique username and password. When the individual enters their password, they are transferred to a secure area of the website which is configured to provide the information that individual requires to perform their job function.

Each individual user is presented with decision support information in a form that best allows them to perform their job function. Available pages include:

- Asset Performance Summary - lists the current profit, optimal profit, and the delta from optimal for all plants in the asset base. Management can quickly review asset performance and focus resources on variance, or problem, resolution.
- Plant Overview - displays operational and engineering summary data for the unit. The Overview screen is completely configurable and any raw or calculated parameter can be displayed. The trend plots can be expanded to full-page view for ease of analysis.
- Profit Sensitivity - displays optimal targets for the key performance parameters that affect unit profitability. Further, the Profit Sensitivity screen displays the financial impact for each process move towards the optimal targets. A summary of overall unit performance is presented along with the pricing basis the optimizer used to develop the optimal targets.
- Parameter Report - displays the financial impact of equipment performance degradation.
- Constraint Report - shows the constraints that are active in the system, the percentage of time they are at their lower or upper constraints, and the possible financial benefit of relieving those constraints.
- Daily Report - automatically developed to help operations people do their job.

Web-based optimization has the added benefit of providing an inexpensive central data repository for gathering, storing, and analyzing plant data from all the disparate DCS systems at the gas plants. This single window into process operations reduces the time, expense, and hassle of daily reporting and allows the report to be more meaningful by including economic performance metrics for each facility.

The ASP business model allows web-based optimization to be provided on a low monthly fee basis with a small upfront activation fee. This allows the service to be cash flow positive almost immediately.

A key aspect of web-based optimization is that all the services required to keep the model matching the plant, the optimizer converging properly, and the communications intact are included in the monthly service fee. Clients are not burdened with:

- Application server or upgrade purchases
- Software license fees or software maintenance fees

- Model development or maintenance fees
- Having to devote internal resources to keep the system operating

This assures that the web-based optimization system will provide value over the duration of the contract term.

Web-based optimization provides comprehensive decision support for the key organizations responsible for plant profitability. It helps processors address the challenges they face and provides support organizations with a tool to help them maximize the profitability of the unit as follows:

Operations

Operators are provided with the information they need to understand the impact of their actions on plant profitability as shown in Table 3:

Table 3 - Achieving Operations' Requirements

Operations	
• Current vs. optimal process profit performance	• **Achieves**
• Guidance to achieve optimal performance	• **Achieves**
• Decision support for local troubleshooting of process problems	• **Achieves**
• Sound control infrastructure	• **Compliments**

Process Engineering

Web-based optimization provides the information required for engineers to support more plants effectively and to be focused on process improvements rather than fighting fires (Table 4).

Table 4 - Achieving Engineering's Requirements

Process Engineering	
• Window into the process	• **Achieves**
• Performance monitoring for individual process equipment and the entire plant	• **Achieves**
• Remote troubleshooting ability	• **Achieves**
• Identify the financial impact of equipment performance degradation	• **Achieves**
• Analysis of the constraints the facility is working within and an indication of the financial benefit of removing those constraints	• **Achieves**

Management

Management benefits from a clear compilation of plant performance and a comparison of current versus optimal operation for the unit (Table 5). Resources can be focused on proactively responding to abnormal situations, or on profit enhancement opportunities, rather than reactively trying to troubleshoot process operations.

Web-based optimization eliminates the tedious effort associated with gathering plant data, calculating performance metrics, and assimilating them into a standard reporting format. More importantly, the reporting process can now be supplemented with additional performance data which was previously unavailable.

Table 5 - Achieving Management's Requirements

Management	
• Window into the process	• **Achieves**
• Summary of asset performance for each plant	• **Achieves**
• Ability to "drill down" and monitor what is happening at each plant.	• **Achieves**
• Highly value adding, robust, and maintainable solutions	• **Achieves**

Web-based optimization was applied to an Enogex gas processing plant in western Oklahoma. The web-based optimization system returned all first year fees, and a large portion of second year fees, in the first month of operation. When considering the small upfront activation fee, and low monthly service fee, an overall return exceeding 500% was identified during the first seven months of operation.

Other benefits include:

- Immediate access to plant performance information throughout the organization. Information included not only process measurements but also plant and equipment performance ratings and trends.
- Information customizable by individuals in management, operations, engineering, marketing, and maintenance to satisfy their information needs in supporting the asset.
- The ability to view and optimize assets with varying control infrastructure.
- The system can be deployed in approximately two months so benefits can be realized quickly.

- Several instrumentation issues were identified such as mis-calibration of fuel flow transmitters and an analyzer being stuck in calibration mode.
- Enogex also realized benefits in being able to run the plant to commodity pricing and fully exploit market opportunities identified by the commercial group.

The best example of value generation occurred during a period of ethane rejection when the optimizer provided guidance that the most advantageous mode of operation was to shutdown one partially loaded compressor and bypass a portion of the inlet gas stream around the plant. A direct benefit of $3,500/day in fuel savings was netted against propane and heavier NGL upgrade value in the bypassed gas.

Enogex is leveraging this experience into a strategic deployment of web-based optimization to other Enogex facilities.