USING PROCESS SIMULATORS WILL MAKE YOUR PLANT MORE PRODUCTIVE AND EFFICIENT

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ABSTRACT

The use of process simulators to model plant operations can provide a plant hundreds of thousands of dollars each year in increased production and lower energy costs. This paper looks at several example plants where process simulators were utilized to optimize their operation and measurable results were obtained. Each of these plants were able to improve their bottom line profit because a process simulator was available and plant personnel were dedicated to using it to improve plant performance and efficiency.

In today’s economic roller coaster, where product margins can be positive one day and negative the next, a plant must be designed and operated with the utmost operating flexibility, while maintaining high energy efficiency. The process simulator allows both the designer and the operator to maximize this flexibility and determine the best way to operate the plant at both ends of the operating spectrum. Today, a plant that does not use a simulator to monitor its operation is simply throwing money away.

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INTRODUCTION

Process simulators have been in widespread use throughout much of the energy industry for almost 20 years and progress continues to make these programs faster, easier and more accurate in the design and operation of processing plants. Process simulators have become required engineering tools for Design Engineers, Process Engineers and Plant Operators. When properly used, the simulator can aid the Engineer in becoming more productive and creative in performing his job responsibilities. However, many of today's plants are designed without utilizing the simulator's full capabilities to help optimize the plant configuration and overall cost. Additionally, many operating plants haven't been simulated since they were first brought on-line, leading to inefficient operation and uncertainty about how changes in one area of the operation affect other areas of the plant. Understanding how your process simulator works, utilizing all its capabilities and being able to compare simulation results to actual operating conditions will result in a better designed and better operated process plant. Process simulators can and should be used in numerous ways, from improving initial plant designs to increasing operating efficiency and/or product recoveries to performance of parametric studies to determine the effect on plant operation at varying conditions. This paper concentrates on examples of how simulators were used in the design and operation of four different plants and the resulting benefits that were derived in each case.

DISCUSSION

Plant A

This plant was originally designed using a process model taken from an identical plant, operating in parallel to the new plant (Figure 1), and modifying the simulation as required to meet several new design parameters. In addition, the simulation was expanded to include both plants, so that the Operators could predict how a change in one plant's operation would affect the other. During the design phase it was determined that, by sharing the excess residue compression capacity of the new plant with that of the existing plant, the existing plant's inlet rate could be increased by 10 percent, while at the same time increasing product recoveries (Table 1). Thus, by using the simulator to model both plants in parallel operation, the Designer was able to provide the Operator with a feature that would increase plant throughput by an additional 20 MMSCFD and total revenue by over $30 million per year (using $4.50/MMBtu) at a cost of less than $300,000! In this case, use of the simulator and the ability of the Designer to fully utilize it, resulted in a tremendous benefit to the Operator, both monetarily and by strengthening his processing position in the region.

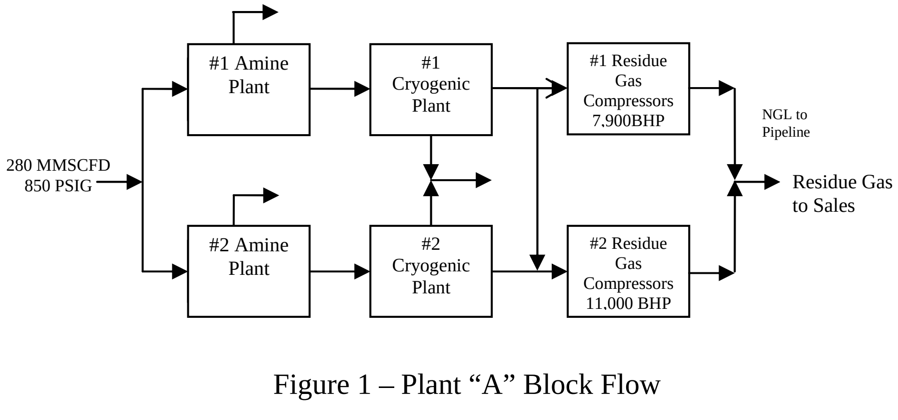

Figure 1 – Plant "A" Block Flow

Table 1 – Plant #1 Performance (Plant A)

	Original	After Plant #2 Installed
Gas Throughput (MMSCFD)	120	140
Residue Compression HP Available	7900	9500
Demethanizer Pressure (PSIG)	235	210
Ethane Recovery (%)	89.5	92.3

During start-up of this plant several common difficulties were encountered. These included compressor start-up problems, product pump problems and loss of the inlet gas treating system. These problems resulted in plant upsets that, at the time, seemed normal to all plant start-ups. However, after being in operation for approximately two months, a plant performance test was run and the plant did not meet the guaranteed product recovery levels (Table 2).

Table 2 – Plant #2 Performance (Plant A)

	% Ethane Recovery	Methane/Ethane LV Ratio
Simulation Prediction	92.8	0.014
Process Guarantee	89.8	0.015
Actual	86.7 - 89.7	0.03+

Simulations were performed on the plant, using actual operating data, and it became apparent that something was wrong with the Demethanizer. The simulation could be “forced” to match the actual operating data almost exactly; but to do this required using tray efficiencies of only 20-25% compared to typical 60-65% tray efficiency for cryogenic Demethanizers (Figures 2A and 2B). Additional tests were performed, including a gamma-ray scan of the tower, and it appeared that tray damage had occurred. The general consensus was that the tray manways had been dislodged from the main trays by pressure excursions in the tower during one or more of the plant upsets. When the column was opened, this was indeed found to be the cause of the problems. Once fixed, the plant was put back on-line and performed extremely close to the design simulation model predictions, exceeding product guarantee levels by three percent. Therefore, while the simulator did not specifically predict what the problem was, it did aid those who used it in determining potential causes for the problem and gave them a path to pursue for further confirmation.

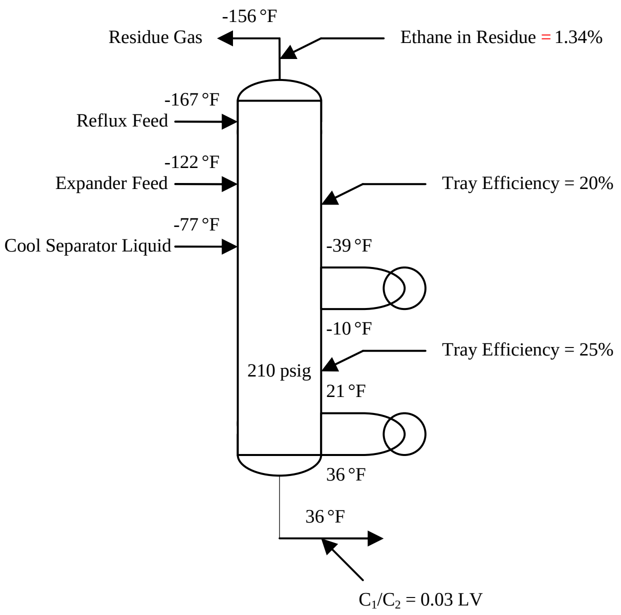

Figure 2A – Plant "A" Actual Performance

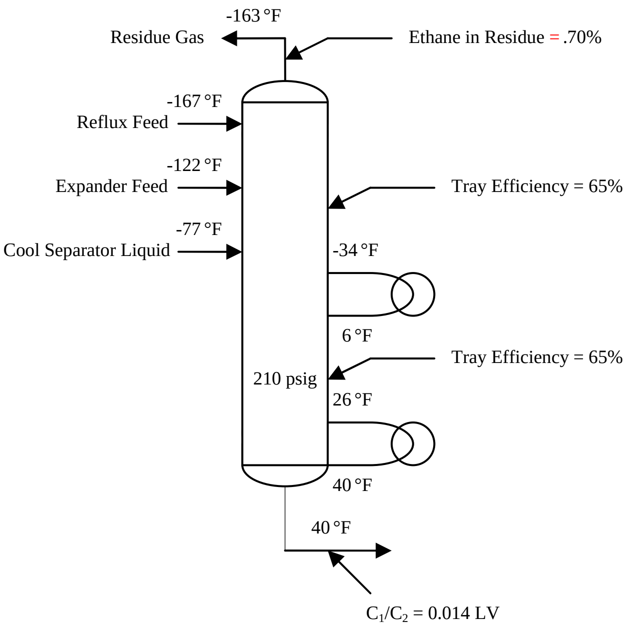

Figure 2B – Plant "A" Design Performance

Plant B

This plant is actually a compilation of several plants, all with various plant processes and operating both in parallel and interwoven with one another (Figure 3).

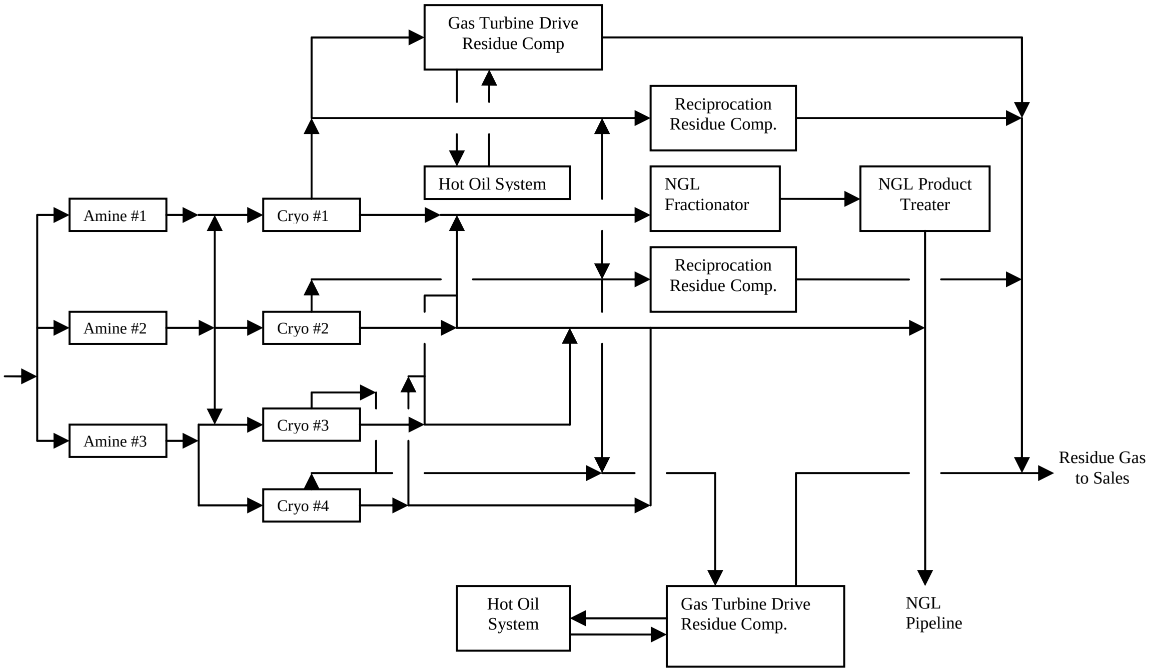

Figure 3 – Plant B Block Flow

As in Plant A above, the Designer had to develop an overall plant model that would accurately depict how all of the plants would interact and the impact a change to one would have on another. Intermingling of plant amine systems and hot oil systems led to higher energy efficiency and lower overall capital costs for the plant. Utilizing a common residue gas header system allowed the Operator to take full advantage of his existing residue gas compression and handle swings in flow and discharge pressure, yet avoid operation of excess compression, thus saving fuel and maintenance costs. Accurate prediction of the different system interactions and determination of how to operate in the most efficient manner possible would have been very difficult and time consuming, without a process simulator.

Several opportunities for improving the efficiency of this plant have arisen over the years and, in each case, a simulator has helped in identifying these areas of improvement. The following lists a few examples of these. On one occasion, it was determined that one Demethanizer was not performing in the manner it should. When the actual temperature profile across the column was inserted into the process simulation, it showed that the side reboiler was providing approximately 95% of the reboiling duty to the tower, while the bottom reboiler was having minimal input (Figure 4A). The design simulation showed that the side reboiler should have only provided 2/3 of the column reboiling duty and, operating in the manner it was, approximately 25% of the column was totally ineffective in the fractionation process. This lowered product recoveries and made it difficult to meet product specifications. Upon inspection, it was noted that the liquid draw to the bottom reboiler had been almost completely "pinched off". This resulted in the side reboiler being supplied with warmer inlet gas as the heat medium and thus providing more heat transfer. The bottom reboiler draw was reopened and the side reboiler draw was pinched back to some degree. Within two hours, the tower temperature profile had been re-established to a point that was very close to the simulation model and product recovery levels reached predicted levels, without encroaching upon specification limits (Figure 4B).

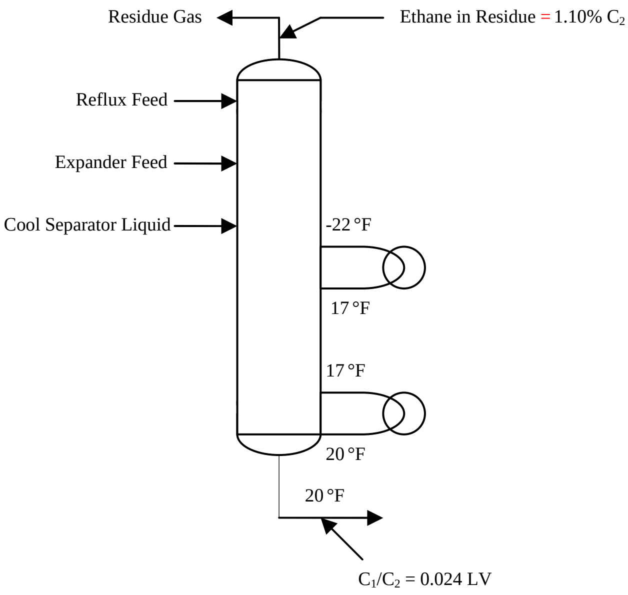

Figure 4A – Plant "B" Actual Operation

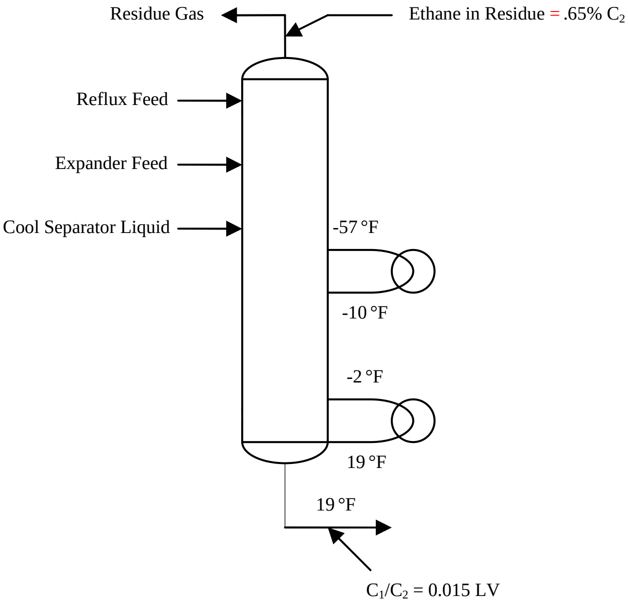

Figure 4B – Plant "B" Design Operation

In this case, the simulation model was used with actual operating data and the Engineer/Operator was able to properly interpret and evaluate the results to pinpoint the problem area.

The hot oil system for this plant has had problems providing sufficient heat duty to the plant, which includes two amine systems, a mol sieve regeneration system and four fractionation tower reboilers. Though the system flow scheme was known and the bottlenecks recognized, the system had never been simulated, nor the reasons for the bottlenecks fully understood (Figure 5).

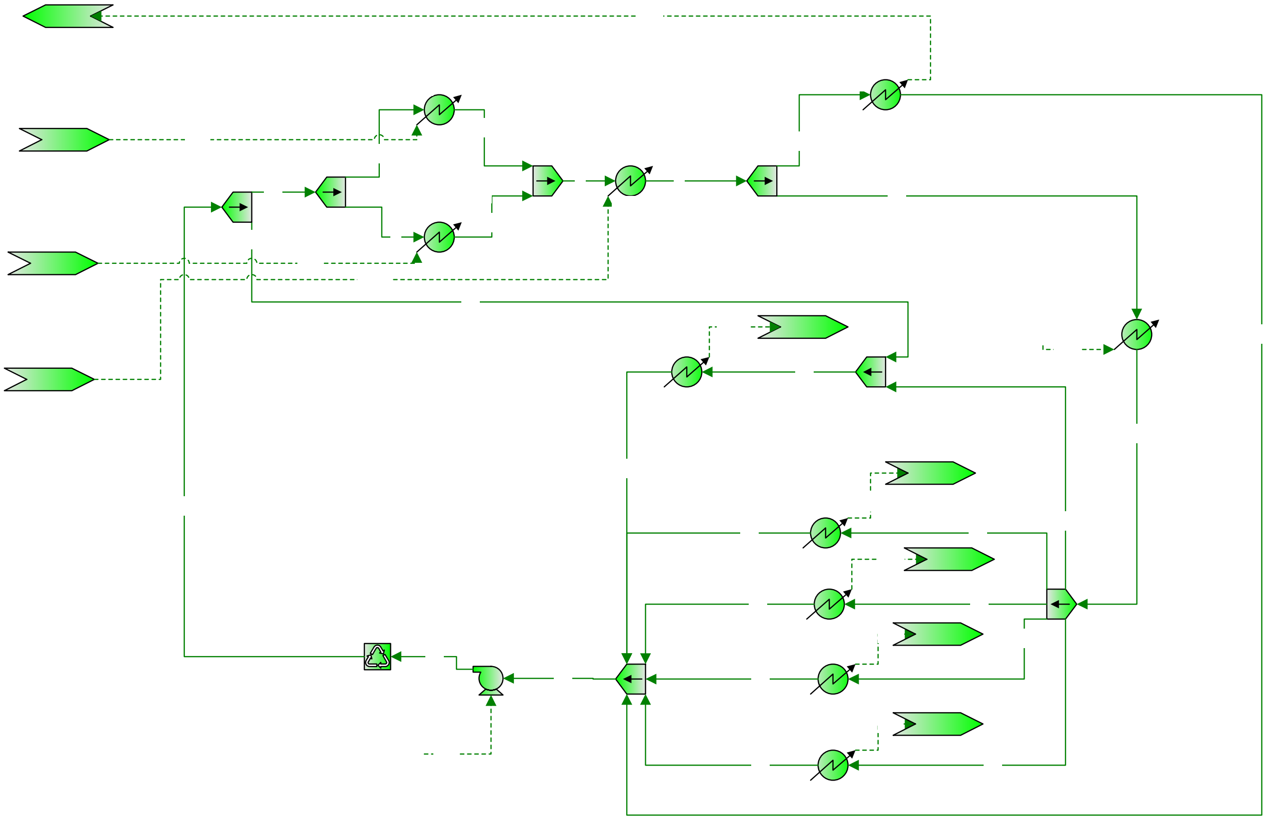

Figure 5 – Plant #1 Heat Medium System

Once the system was modeled, steps were taken to devise modifications that would allow the plant to operate in the most efficient manner possible and provide the required heat to all users on the network. Manipulation of the flow schemes, using the simulator as a drawing board, resulted in a revised piping design that removes some of the inherent inefficiencies of the existing system and insures that all parts of the system receive the required oil flow and heat duty (Figure 6).

Amine Reboiler Duty

W

Q-3

2

WHRU #2 Duty

SPLT-100

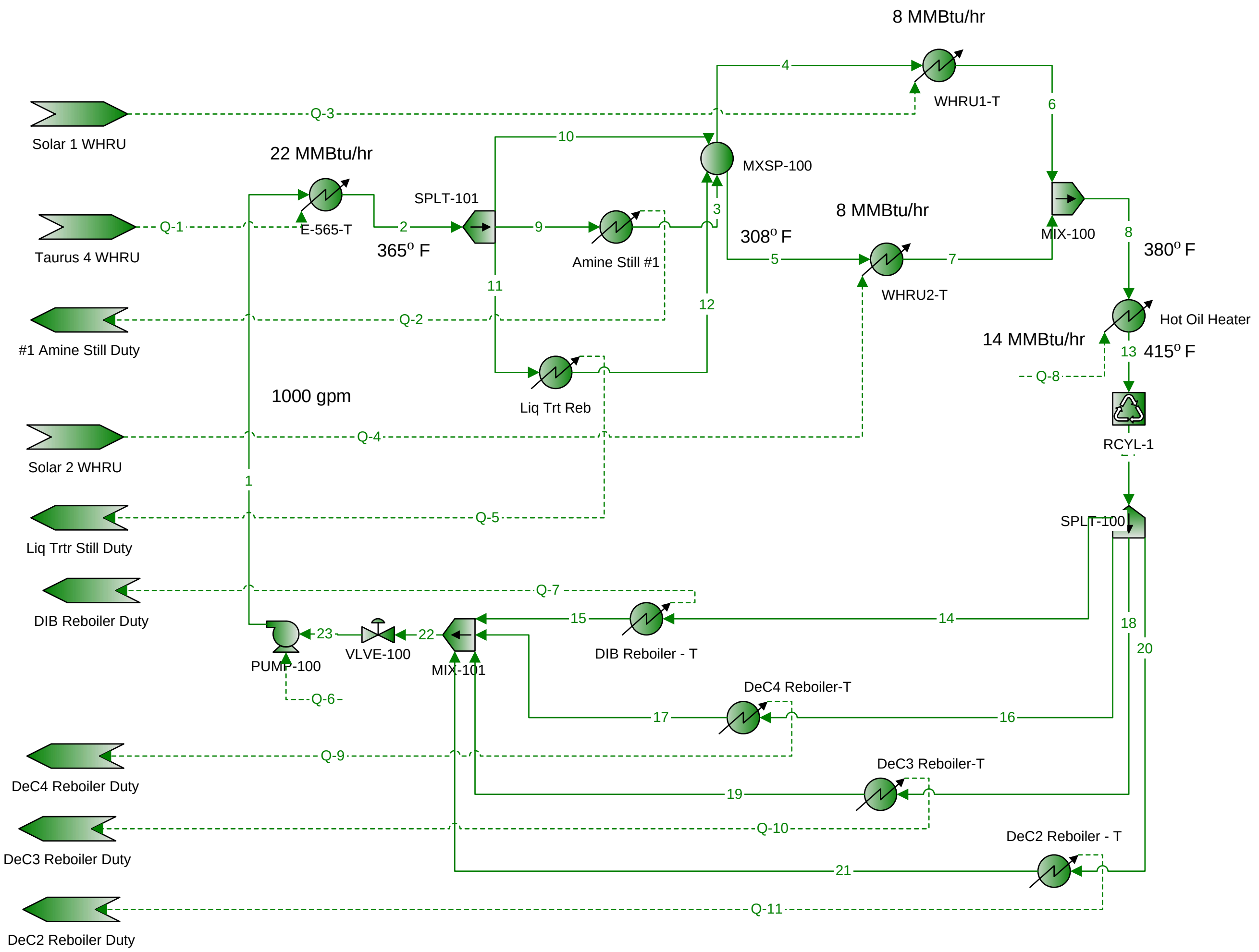

Figure 6 – Proposed Hot Oil System for Plant 1 and Fractionator

Additionally, the new scheme better utilizes the plant's Waste Heat Recovery Units (WHRU's) and will reduce fuel costs by approximately $700,000 per year (Table 3). This example illustrates how the Engineer can use the simulator as a tool for his creativity and solve a problem in a manner that had not been considered before.

Table 3 – Hot Oil System Optimization

	Current	Proposed
WHRU #2 Duty (MMBTU/hr)	8.0	8.0
WHRU #3 Duty (MMBTU/hr)	7.5	8.0
WHRU E-565 Duty (MMBTU/hr)	11.3	22.0
Hot Oil Heater (MMBTU/hr)	26.7	14.0
Fuel Gas Savings (MMBTU/D)	-------	381
Fuel Cost Savings ($/yr) (Bases on $5 / MMBTU)	-------	$700,000

Plant C

This was actually an evaluation of several plants, using a simulator to determine the performance capabilities of each plant to process a given inlet gas stream. Using whatever original design and process data was available for each plant, "base-line" simulation models were developed. Using the information predicted by the simulator (i.e. exchanger UA's, duties, available/required equipment horsepower, etc.) the models were modified to maintain the limiting factors as constant and then the new gas composition and flow rates were introduced. In this manner, the simulator was able to predict how each plant would operate under the new process conditions. It was determined that one plant would perform very well under the specified conditions, but the other plants had several bottlenecks and limitations that resulted in poor performance for the new process parameters.

Simulations were also run on the "acceptable" plant to determine whether or not inlet gas treating should be installed on the front end of the plant, for removal of carbon dioxide (CO2). The simulator was able to predict the level of ethane recovery, without removal of the CO2, and still meet the bottoms product specification and not form solid CO2 within the column. This was then compared to the levels of ethane that could be recovered assuming the CO2 was removed upstream of the cryogenic plant. Economic evaluations were then performed to compare the additional capital required for an amine system versus the additional revenue that might be realized from the extra ethane liquid product. This is another example of how the simulator can be used to check operation of a plant under different inlet conditions.

Plant D

This older design, cryogenic gas plant developed operational problems that prevented the system from meeting historic product recovery levels. In order to determine what factors were causing this drop in performance, the plant was modeled using the original "as-built" specifications and a baseline design operation was developed. The current operating data was then input to the model to aid in pinpointing anomalies in the plant operation. There were significant differences between the temperature profiles of the Demethanizer column predicted by the simulation model and what was actually occurring in the tower. This led the Process Engineer to re-run the simulation model with the inclusion of different dysfunctionalities within the column, primarily short-circuiting of cold liquids through the tower internals. Once a model was developed that could reproduce the actual operation, it was used to justify the expense of a gamma-ray scan of the tower to look for possible abnormalities within the tower. The scan produced evidence that the center section of the tower packing had collapsed, creating the liquid short-circuits and plugging reboiler draws. The plant is expected to return to historic recovery levels when the tower packing and support trays have been replaced. Like Plant A above, this example shows how a process simulator can be used to test various theories and point the Engineer and/or Operator in the right direction to solving his problems.

CONCLUSIONS

Full utilization and proper use of a process simulator provides the Design Engineer a powerful tool to develop the most cost effective and efficient design for a processing plant. Similarly, simulators can be used by both the plant Engineer and Operator to increase productivity and efficiency within an operating plant. However, process simulators are tools and not magic black boxes that provide you with every answer. Designers and Operators alike should expend the effort necessary to learn and understand the capabilities of their simulator of choice and use the simulator on a routine basis to maintain familiarity with the program. They should also take advantage of any customer support and training that the simulator software provider may provide.

Using a little creativity and a lot of common sense, process simulators will help make your plant more productive and efficient. If your company designs or operates any type of processing plant, but you do not have a process simulator or people who know how to use them, you are likely losing untold amounts of money. The cases cited above are more the norm than the exception. In each example, the savings to both the Designer and the Operator were tremendous in both time and money and gave each a competitive advantage in the marketplace, since they were more cost effective and efficient.