Case Study 1 – Process Plant Incremental Expansion

Process plant incremental expansion, sometimes called 'debottlenecking', is often applied to existing plants that produce product(s) in a growing market. Successful debottlenecking of oil refineries over the past 40 years has enabled the refining industry to meet product demand without having built a single new refinery in that period. The key to successful, low cost, debottlenecking is to understand not only the existing plant limitations (equipment related, control related, or human factor related), but also to understand the maximum capacity of each individual piece of (major) equipment in the process. It is well known that individual equipment in every plant has been overdesigned to some degree (either by the process engineer to comfortably meet the original nameplate capacity, or by the equipment vendor to meet their guarantee, and most likely a combination of both). The debottlenecking process should understand and leverage this certainty.

Debottlenecking methodology developed by this consultant provides a systematic approach to understanding the synergy among the existing plant equipment, mapping the most efficient and lowest cost route to a predetermined production improvement goal. A process simulation model of the entire plant process is critical in providing the foundational data that defines the existing and future operating rates. Artificially increasing plant production rate in the process model then provides capacity relationships for each piece of plant equipment over increasing production rates.

As an example, using a corn ethanol plant producing 19 million gallons per year (19 MGY), the operations management wanted to understand the cost of increasing the plant production rate to a range of 36 to 40 MGY. Using an Aspen Plus® process model in representing the entire process, equipment capacity relationships were developed for each major piece of process equipment (36 unit operations in this case, consisting of distillation columns, scrubbers, heat exchangers, reactors, evaporators, centrifuges, and utilities). Figure 1 below provides an example relationship:

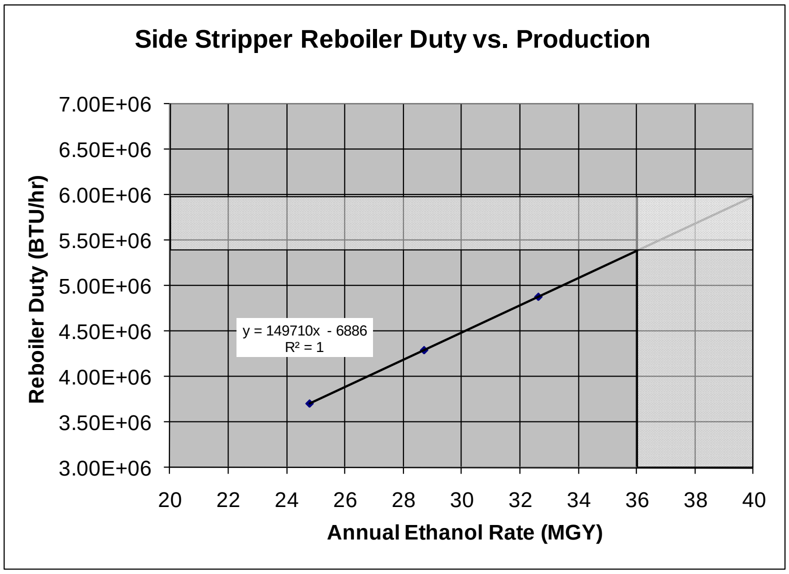

Figure 1 - Side stripper reboiler capacity response over an ethanol production range

For the 36 unit operations in this process, response curves (some linear, some not) and their corresponding line equations are subsequently catalogued in a spreadsheet.

The next step is to determine the actual capacity of each piece of equipment. This knowledge can either be rigorously determined (using Aspen Shell & Tube® to calculate the actual capacity of a shell and tube heat exchanger, for instance), or estimated from the original equipment data sheet. This information can then be combined with the relationships established above to map the progressive debottlenecking plan.

Item	Item Capacity		Projected Ethanol Capacity (MGY)
1 CO2 Scrubber	45	gpm	19.1
2 Evaporator Rate	32350	lbs/hr	20.5
3 Side Stripper Reboiler Duty	4.00E+06	BTU/hr	26.7
4 PHE Duties			27.0
5 Ferm Cycle	48	hrs	27.9
6 Mol Sieve Feed	85	gpm	28.0
7 Plant Pumps			28.0
8 Mol Sieve Vaporizer Duty	1.87E+07	BTU/hr	29.3
9 Boiler Rate	83000	lbs/hr	29.5
10 Beer Column Vapor Flooding	100%	% of Flood	32.2
11 Boiler NOx Limitation		lbs/hr	33.0
12 CT Duty	9.80E+07	BTU/hr	37.4
13 190 Condenser Duty	3.77E+07	BTU/hr	37.7
14 Beer Reboiler Duty	5.55E+07	BTU/hr	39.5
15 DDG Dryer Evap Rate	38000	lbs/hr	39.9
16 Product Cond. Duty	2.00E+06	BTU/hr	41.0
17 Plant Water Makeup	936000	GPD	44.1
18 Rectifier Vapor Flooding	100%	% of Flood	45.0
19 Evaporator Cond. Duty	1.92E+07	BTU/hr	45.3
20 Centrifuge Feed	500	gpm	49.0
21 Cook Water Heater	4.50E+06	BTU/hr	51.8
22 Product Cooler Duty	7.50E+05	BTU/hr	59.0
23 Corn Feed	168000	lbs/hr	64.1

Figure 2 - Equipment capacities and corresponding plant production rates

Figures 3, 4, and 5 summarize this information in a logical progression:

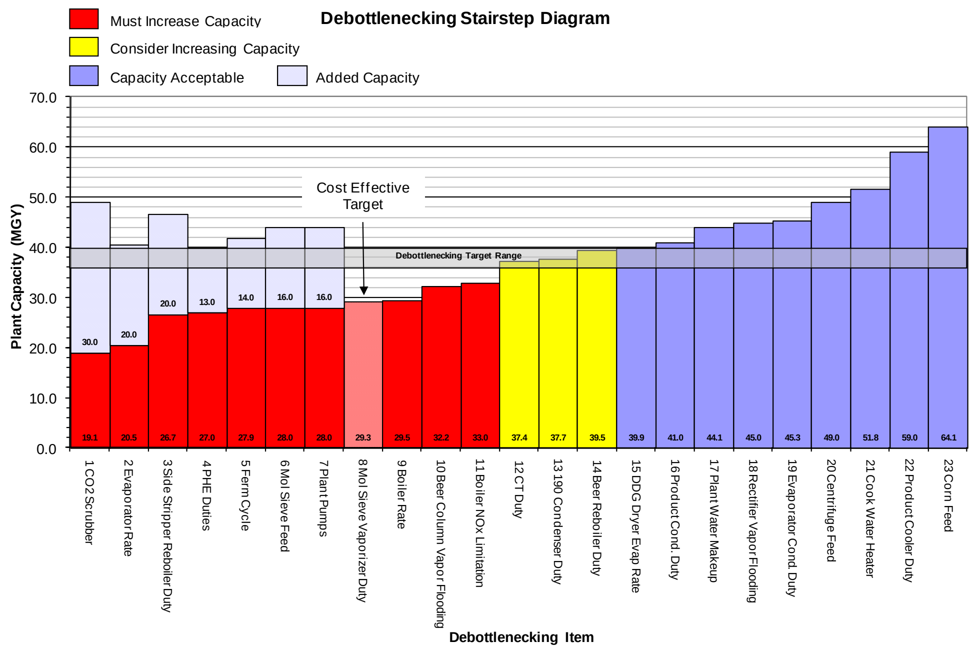

Figure 3 - Debottlenecking stair-step diagram

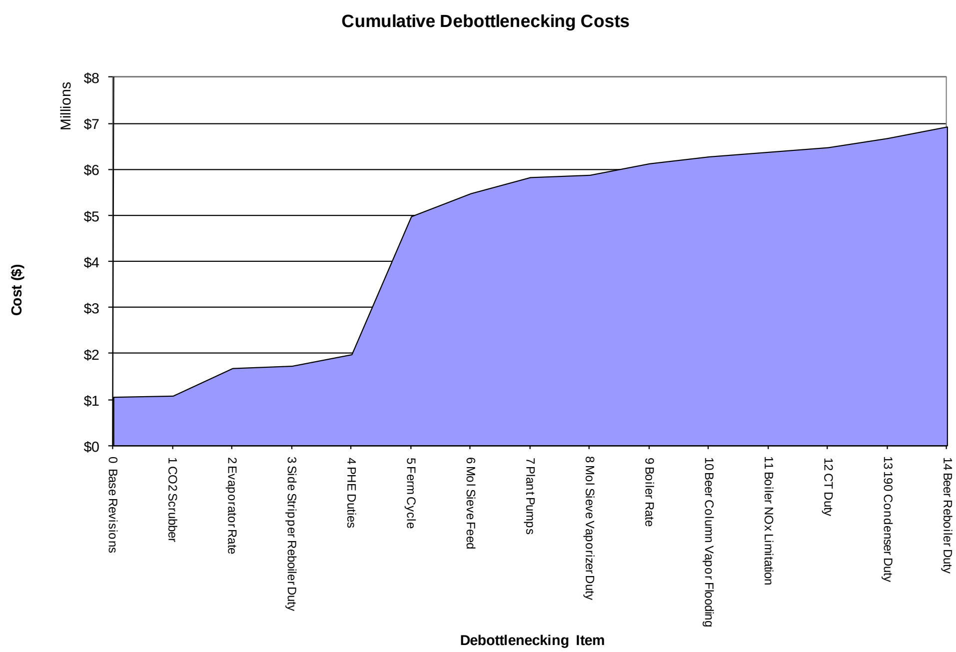

Figure 4 - Cumulative cost to removing equipment bottlenecks

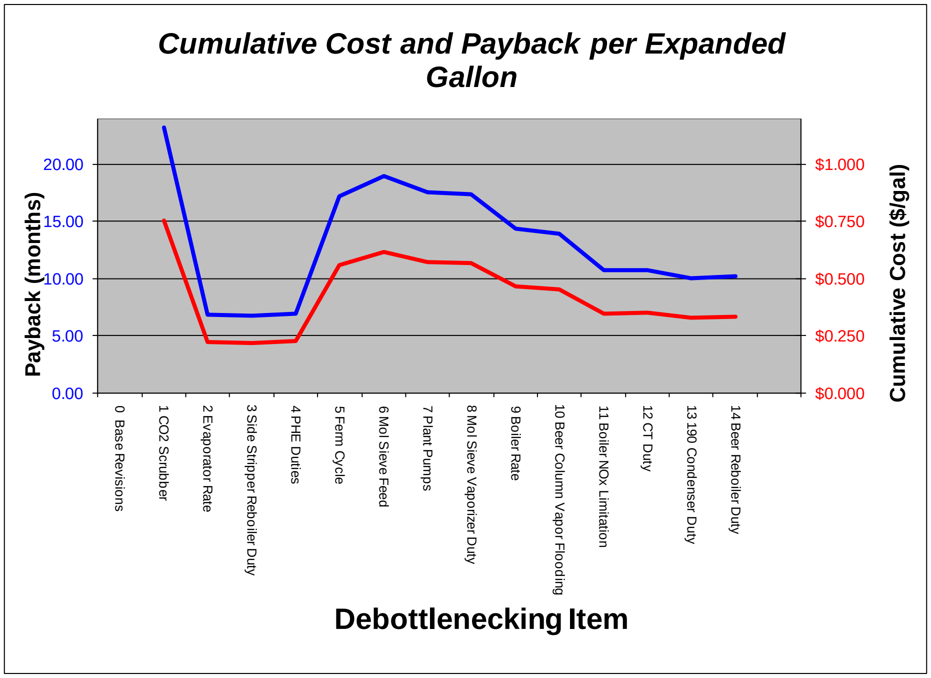

Figure 5 - Progressive return on incremental investment

With this data, the final conclusion was not to debottleneck to the original target, but to stop at 28 MGY, where return on investment was highest (the plant had already invested in removing bottlenecks out of order prior to conducting the study).